A GUIDE

TO THE

SCIENTIFIC KNOWLEDGE

OF THINGS FAMILIAR;

BY

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PREFACE TO THE THIRD EDITION.

No science is more generally interesting, than that which explains the common phenomena of life. We see that salt and snow are both white. a rose red, leaves green, and the violet a deep purple ; but how few persons ever ask the reason why ! We know that a flute produces a musical sound, and a cracked bell a discordant one—that fire is hot, ice cold, and a candle luminous—that water boils when subjected to heat, and freezes from cold ; but when a child looks up into our face and asks us " why,"—how many times is it silenced with a frown, or called "very foolish for asking such silly questions !" The object of the present book is to explain about 2000 of these questions (which are often more easily asked than answered) in language so simple that a child may understand it, yet not so childish as to offend the scientific. In order to secure the strictest accuracy in the answers, the most approved modern authors have been consulted, and each edition has been submitted to the revision of gentlemen of acknowledged reputation for scientific attainments. Sincere thanks are due to the Rev. A. Bath Power, M. A., and to Robert James Mann, Esq. of Buxton, for their most careful revisions of the whole book, for many excellent hints, and useful additions.*

* Mr. Simeon Simons, of Cromer, furnished some useful hints for the second edition.

In conclusion, the almost unparalleled success of this little volume, of which 10,000 copies have been printed in 12 months, is an incontrovertible proof of its acceptability; and has induced the author to spare neither labour nor expense to render this third edition of the "Guide to the Scientific Knowledge of Things Familiar" instructive and amusing to the young, as well as to those of maturer life.

To teachers of schools it may be advisable to state, that, as every question has been again and again submitted to a most rigid investigation, no material alterations will be made in future editions; although such as may be needful, to render the book most generally useful, shall be adopted from time to time, as subsequent reprints may be demanded.

King's College School, Norwich,
Feb. 1st, 1849.

SUBJECTS OF THE CHAPTERS.

PART I.—HEAT

PART II.—AIR.

PART I.

HEAT.

INTRODUCTION.

Q. *What is heat?*

A. The sensation of warmth.

Q. *How is this sensation produced?*

A. When we touch a substance of higher temperature than ourselves, *a subtle invisible stream* flows from the *hotter substance,* and produces in our nerves the sensation of warmth.

Q. *What is that "subtle invisible stream" called, which flows thus from one body to another?*

A. CALO'RIC. *Caloric,* therefore, is the *agent,* which produces the *sensation of warmth;* but HEAT is the *sensation* itself, produced by the influx of Calo'ric.

Q. *What are the four principal* SOURCES *of heat?*

A. 1.—The Sun. 2.—Electricity. 3.—Chemical Action; and 4.—Mechanical Action.

Q. *What are the principal* EFFECTS *of heat?*

A. Expansion, Liquefaction, Vaporization, and Ignition.

CHAPTER I.

Q. *What is the* PRINCIPAL *source of Heat?*

A. The SUN.

Q. *Why do* BURNING GLASSES *set fire to substances submitted to their power?*

A. Because the rays of the sun, collected by the Burning Glass, are all bent (as they pass through it) *to one point,* called the "focus;" in consequence of which, the light and heat of *this point* are very greatly increased.

Q. *Why is there a* DARK RIM *round this focus?*

A. Because the rays of light, which should have fallen there, are *bent into the focus*; and the space around (being deprived of these rays) is accordingly darkened.

Q. *Are* ALL *the rays bent into one point?*

A. No, not quite all: and, therefore, the rim round the focus is only *slightly* shadowed.

CHAPTER II.

Q. *What is the* SECOND *chief source of Heat?*

A. ELECTRICITY.

Q. *What is* LIGHTNING?

A. Lightning is *accumulated Electricity* discharged *from the clouds.*

Like that from a "Leyden jar."

Q. *What causes the discharge of an electric cloud?*

A. When a cloud *overcharged* with electric fluid approaches another which

is *under-charged,* the fluid rushes from the former into the latter, till both contain the same quantity.

N.B. Some persons think there are two different *sorts* of Electricity—one Vitreous, and the other Resinous.

Q. *Is there any* OTHER *cause of lightning, besides the one just mentioned?*

A. Yes; sometimes mountains, trees, and steeples, will discharge the lightning *from a* cloud floating near; and sometimes electric fluid rushes *out of the earth* into the clouds.

Q. *What produces* ELECTRICITY *in the* CLOUDS?

A. 1st—The *evaporation* from the earth's surface;

2ndly—The *chemical changes* perpetually going on upon the earth's surface; and

3rdly—Currents of air of unequal temperature excite electricity by *friction,* as they pass by each other.

Q. *How* HIGH *are the* LIGHTNING-CLOUDS *from the earth?*

A. Electrical clouds are the *lowest of all clouds;* they are rarely more than 700 yards above the ground; and

sometimes they actually *touch the earth* with one of their edges.

Q. *How high are the clouds* GENERALLY?

A. In a *fine* day, the clouds are often 4 or 5 miles above our head; but the *average* height of the clouds is from 1½ to 2 miles.

Q. *Why is lightning sometimes* FORKED?

A. Because the lightning-cloud is a *long way off;* and the *resistance of the air* is so great, that the electrical current is diverted into a zig-zag course.

Q. *Why does the resistance of the air make the lightning zig-zag?*

A. As the lightning *condenses* the air in the immediate advance of its path, it keeps flying from side to side, in order to pass where there is the *least resistance.*

Q. *Why are there sometimes* TWO *flashes of forked lightning at the same moment?*

A. Because (in very severe storms) a flash of lightning will divide *into two or more parts;* and then each branch assumes the zig-zag form.

Q. *Why is the* FLASH *sometimes quite* STRAIGHT?

A. Because the lightning-cloud hovers *near the earth;* and as the flash meets with very little resistance it is *not diverted;* or (in other words) the flash is straight.

Q. *What is* SHEET LIGHTNING?

A. It is either the *reflection of distant flashes* not distinctly visible: or else several flashes intermingled.

Q. *What* OTHER *form does lightning occasionally assume?*

A. Sometimes the flash assumes a *globular form;* which is the most *dangerous* form of lightning.

Q. *What are those* BALLS *of* FIRE, *which sometimes fall to the earth in a thunder-storm?*

A. Masses of explosive gas formed in the air: they generally move much slower than lightning.

Q. *Why are* BALLS *of* FIRE *so very* DANGEROUS?

A. Because they explode, like a cannon, when they fall; and occasion much mischief.

Q. *Do these* BALLS OF FIRE *ever run along the ground?*

A. Yes; sometimes they run a considerable way along the ground, and explode *in a mass:*

At other times they will *split* into numerous *smaller balls*, each of which will explode in a similar manner.

Q. *What* MISCHIEF *will these balls of fire produce?*

A. They will set houses and barns on fire; and kill all cattle and human beings, which happen to be in their course.

Q. *Why does* LIGHTNING *sometimes* KILL *men and beasts?*

A. Because, when the electric current passes through a man or beast, it produces so *violent an action upon the nerves*, that it destroys life.

Q. WHEN *is a person struck* DEAD *by lightning?*

A. Only when his body forms a part of the *lightning's path;* i. e. when the electric fluid (in its way to the earth) actually passes *through his body.*

Q. *Why are* MEN *sometimes* MAIMED *by lightning?*

A. Because the electric fluid produces an *action upon the nerves sufficient* to *injure* them, but not to *destroy life*.

Q. *What is* THUNDER?

A. The noise made by the concussion of the air when it *closes* again, after it has been parted by the lightning flash.

A part of the noise is owing to the *chemical changes* produced in the air by the electric fluid.

Q. *Why does lightning* PART *the air through which it passes? it does not part a rod of iron.*

A. As iron is a *conductor*, it allows the fluid to pass *freely over it*: but air being a *non-conductor*, *resists* its passage.

Q. *Why is* THUNDER *sometimes* ONE VAST CRASH?

A. Because the lightning-cloud is *near the earth;* and as all the vibrations of the air (on which sound depends) reach the ear at *the same moment,* they seem like *one vast sound.*

Q. *Why is the* PEAL *sometimes an* IRREGULAR *broken* ROAR?

A. Because the lightning-cloud is a long way off; and as *some* of the vibrations of the air have much further to travel than

others, they reach the ear at *different times,* and produce a *continuous sound.*

Q. *Why would not all the* SOUND-WAVES *reach the ear at the same time, if they had far to travel?*

A. Because sound takes a whole *second of time* to travel 380 yards; if, therefore, the cloud were 1000 yards off, we should hear the vibrations of the *lowest* strata of air nearly *three seconds* before we heard those in the immediate vicinity of the cloud.

Q. *What is meant by "* STRATA *of air?"*

A. If a board were laid upon the earth, and several other boards piled upon it, this pile would represent strata of wood.

Q. *How does this illustration apply to the air?*

A. A layer of air covers the earth; another layer rests upon *it;* and thus, layer is piled upon layer for 50 miles in height. Each layer is a "stratum" of air; and the *plural* of stratum is "strata."

Q. *Why is the* THUNDER *sometimes like a deep* GROWL?

A. Because the storm is *far distant*, and the sound of the thunder indistinct.

Q. *Does not* SCENERY *affect the sound of thunder?*

A. Yes; the *flatter* the country the more unbroken the peal. *Mountain* scenery *breaks* the peal, and makes it harsh and irregular.

Q. *What is the cause of* ROLLING THUNDER?

A. Because the vibrations of air (having *different lengths* to travel) reach the ear at *successive intervals*.

The reverberation (or echo) amongst the massive clouds contributes in some measure to this effect.

Q. *Why is a flash of lightning generally followed by a* POURING RAIN?

A. The flash produces a change in the *physical condition of the air*, and renders it unable to hold so much water in solution as it could before; in consequence of which, a part is given off in heavy *rain*.

Q. *Why is a flash of lightning generally followed by a* GUST OF WIND?

A. Because the *physical condition of the air* is disturbed by the passage of the

lightning, and wind is the result of this disturbance.

Q. *Why is there* NO THUNDER *to what is called* SUMMER LIGHTNING?

A. Because the lightning-clouds are *so far off*, that the sound of the thunder is *lost*, before it reaches the earth.

Q. *Do* THUNDER-BOLTS *ever drop from the clouds?*

A. No; the notion of *thunder-bolts* arises, either from the *globular* form occasionally assumed by a flash of lightning; or else from the gaseous *fire-balls* which sometimes fall from the clouds. (p. 6.)

Q. *Why is the* THUNDER *often several moments* AFTER *the* FLASH?

A. Lightning travels nearly *a million* times faster than thunder; if, therefore, the thunder has *far to come*, it will not reach the earth till a considerable time *after the flash*.

Q. *Can we not tell the* DISTANCE *of a thunder-cloud, by observing the interval which elapses between the flash and the peal?*

A. Yes; the flash is *instantaneous,** but thunder will take a whole *second of time* to travel 380 yards: hence, if the flash be 5 seconds before the thunder, the cloud is 1900 yards off.

(i. e. 380 × 5 = 1900 yards.)

Q. *What* PLACES *are most* DANGEROUS *during a* STORM?

A. It is very dangerous to be near a tree, or lofty building; and also to be near a river, or any running water.

Q. *Why is it* DANGEROUS *to be* NEAR *a* TREE, *or lofty building, during a thunder-storm?*

A. Because a tall pointed object, (like a tree or spire,) will frequently *discharge* a lightning-cloud; and if any one were standing near, the lightning might diverge from the tree, to pass through the fluids of the human body.

Q. *How can a* TREE *or* SPIRE DISCHARGE *a lightning-cloud?*

A. A lightning-cloud (floating over a *plain)* may be *too far off* to be dis-

* The speed of lightning is so great, that it would go 480 times round the earth in one minute: whereas thunder would go scarcely 13 miles in the same space of time.

charged by it; but as a tree, or spire, would *shorten* this distance, it might no longer be too far off to be discharged.

For example. If a lightning cloud were 700 yards above the earth, it would be *too far off* to be discharged:—but a tree or spire 50 feet high would make the cloud only 650 yards off a conductor, and the cloud would be instantly *discharged.*

Q. *Is not* AIR *a* CONDUCTOR *of lightning?*

A. No; dry air is *not* a conductor of lightning.

Q. *Why would it be dangerous to stand near a tree or spire, while lightning is passing down it?*

A. Because the electric fluid (called lightning) always rushes down the *outside* of the tree or spire; and if any one were standing near, might diverge from the tree to pass through the fluids of the human body.

Q. *Does lightning go through the inside or* OUTSIDE *of a tree?*

A. It runs down the *outside* of a *tree;* but passes through the *inside* of a *man.*

Q. *Why does lightning pass down the* OUTSIDE *of a tree?*

A. Because it always makes choice

of the *best conductors:* and the *outside* of a tree is a better conductor than the inside.

Q. *Why does lightning pass through the* INSIDE *of a man?*

A. Because the *fluids* of the human body make a better conductor than the *skin;* therefore lightning passes *through* a man, and not down his skin.

Q. *Why is it* DANGEROUS *to be near a deep* RIVER, *or any other running water, during a thunder-storm?*

A. Because running water is a good conductor; and lightning always takes in its course the *best conductors.*

Q. *Why is it dangerous for a man to be* NEAR WATER, *in a thunder-storm?*

A. Because the *height of a man* may be sufficient to discharge a cloud: and (if there were no *taller* object nigh) the lightning might make the *man* its conductor to the water.

See note on p. 13.

Q. *Why is it* DANGEROUS *to* RING CHURCH-BELLS *during a thunder-storm?*

A. For two reasons: 1st—Because

the steeple may *discharge* the lightning-cloud, in consequence of its mere *height.*

2ndly—The swinging of the bells *puts the air in motion,* and diminishes its *resistance* to the electric fluid.

Q. *Why is it unsafe to* RUN *or* DRIVE FAST *during a thunder-storm?*

A. Because it produces a *current of air;* and, as air in motion affords *less resistance* to the flash, it is a better conductor than *air in a state of rest.*

Q. *What* PARTS *of a* DWELLING *are most* DANGEROUS *during a thunder-storm?*

A. The fire-place, especially if the fire be *lighted;* the attics and cellar. It is also imprudent to sit close by the walls; to ring the bell; or to bar the shutters, during a thunder-storm.

Q. *Why is it* DANGEROUS *to sit* BEFORE *a* FIRE *during a thunder-storm?*

A. Because the heated air and soot are conductors of lightning; especially when connected with such excellent conductors as the stove, fender, and fire-irons.

Q. *Why are the* ATTICS *and* CELLAR DANGEROUS *during a thunder-storm?*

A. As lightning sometimes passes *from the clouds* to the earth, and sometimes *from the earth* to the clouds; therefore, the *middle storey* of a house is safest to be in during a thunder-storm.

Q. *When does lightning pass* FROM THE EARTH *to the* CLOUDS?

A. When the clouds are in a "negative" state of electricity.

Q. *When does lightning pass* FROM THE CLOUDS *to the* EARTH?

A. When the clouds are in a "positive" state of electricity.

Q. *What is meant by the clouds being in a "positive state of electricity?"*

A. When the clouds contain *more* electric fluid than they *generally* do, they are said to be in a "*positive* state of electricity."

Q. *What is meant by the clouds being in a "negative state of electricity?"*

A. When the clouds contain *less* electric fluid than they ought to do, they are said to be in a "*negative* state of electricity."

Q. *Does the flash proceed from a negative or* POSITIVE *body?*

A. Always from a *positive* body, or one over-charged with electric fluid.

Some men of science think there are two *sorts* of electricity, one called VITREOUS, corresponding to *positive* electricity; and the other called RESINOUS, corresponding to *negative* electricity.

Q. *When lightning flashes from the earth to the clouds, what is the flash called?*

A. It is called the "returning stroke;" because the earth (being over-charged with electric fluid) *returns* the surplus quantity to the clouds.

Q. *Why is it* DANGEROUS *to lean* BACK AGAINST A WALL *during a thunder-storm?*

A. Because the electric fluid sometimes runs down the *wall* of a house or room; and (as a man is a better conductor than a brick wall) would diverge from the wall to him.

Q. *Why is it dangerous to* RING *a* BELL *during a thunder-storm?*

A. Bell-wire is an *excellent conductor;* and (if a person were to touch the bell-handle) the electric fluid, passing down the wire, might run through his hand and injure it.

Q. *Why would the lightning run through a man touching a bell-handle?*

A. Because the human body is a better conductor than the *wall* (between the bell-handle and the floor); and as lightning always chooses the *best* conductor for its path, it would (in this case) pass through the *man*, and injure him.

Q. *Why is it* DANGEROUS *to* BAR *a* SHUTTER *during a thunder-storm?*

A. The iron shutter-bar is an *excellent conductor;* and the electric fluid might run from the bar *through the person touching it,* and injure him.

Q. *Why is it dangerous to be in a* CROWD *during a thunder-storm?*

A. For two reasons. 1st—Because a *mass* of people form a *better conductor* than an individual: and

2ndly—The *vapour* from a crowd *increases the danger* of such a place.

Q. *Why is a* MASS *of bodies a better conductor than a single body?*

A. *Each* living body is a *conductor of electricity;* and a connected *mass* of such conductors is more likely to be struck, than a *single individual.*

Q. *Why is the danger increased by the* VAPOUR *which rises from a crowd?*

A. *Vapour* is a conductor, and therefore, may determine the shock; especially when connected with so many living bodies.

Q. *Why is a* THEATRE *dangerous during a thunder-storm?*

A. Because the *crowd assembled* there, and the *great vapour* arising from so many living bodies, render a theatre an *excellent conductor of lightning.*

Q. *Why is a* FLOCK *of sheep in greater danger than a smaller number?*

A. 1st—Because *each* sheep is a *conductor* of lightning, and the conducting power of the *flock* is increased by its *numbers:* and

2ndly—The very *vapour* arising from a flock of sheep *increases its conducting power,* and its danger.

Q. *Why is a* HERD *of cattle in danger during a storm?*

A. 1st—The *number* of living bodies increases the conducting power of the *animal fluids:* and

2ndly—The very *vapour* arising from a herd increases its conducting power.

Q. *If a person be* ABROAD *in a thunder-storm, what place is the* SAFEST?

A. Any spot about 20 or 30 feet from some tall tree or building; unless that spot be near to running water.

Q. *Why would it be safe to stand* 20 *or* 30 *feet from some tall tree, in a thunder-storm?*

A. Because the lightning would always choose the *tall tree* as a conductor, rather than the *shorter man;* and he would not be sufficiently *near* the tree, for the lightning to diverge from it to *him.*

Q. *If a person be in* A CARRIAGE *in a thunder-storm, in what way can he travel most* SAFELY?

A. He should not lean *against* the carriage; but sit upright, without touching any of the four sides.

Q. *Why should not a person lean* AGAINST *the carriage in a storm?*

A. Because the electric fluid might run down the sides of the carriage; and (if a person were leaning against the

sides) would make choice of *him* for a conductor, and perhaps destroy life.

Q. *If a person be in* A HOUSE *during a thunder storm, what place is* SAFEST?

A. Any room in the *middle storey*. The middle of the room is best; especially if you place yourself on a mattress, bed, or hearth-rug.

Q. *Why is the* MIDDLE STOREY *of a house* SAFEST *in a thunder-storm?*

A. Because, even if the fluid *struck* the house, its strength would be exhausted before it reached the middle storey.

Q. *Why is the* MIDDLE *of the* ROOM *more* SAFE, *than any other part of it, in a thunder-storm?*

A. Because, if the lightning struck the room at all, it would come down the *chimney* or *walls* of the room; and therefore, the further distant from these, the better.

Q. *Why is a* MATTRESS, BED, *or* HEARTH-RUG *a good security against injury from lightning?*

A. Because they are all *non-conductors;* and, as lightning always takes in its course the *best* conductors, it would not select such things as these.

Q. *Is it better to be* WET *or dry during a storm?*

A. To be *wet:* if a person be in the open field, the best thing he can do, is to stand about 20 feet from some tree, and get *completely drenched to the skin.*

Q. *Why is it better to be* WET *than dry?*

A. Because the *wet clothes* would form a *better conductor* than the *fluids of our body;* and, therefore, lightning would pass down the wet clothes, *without touching our body at all.*

Q. *What is the* SAFEST *thing a person can do to avoid injury from lightning?*

A. He should draw his bedstead into the middle of his room, commit himself to the care of God, and go to bed; remembering that our Lord has said, "The very hairs of your head are all numbered."

N.B. No great danger needs really to be apprehended from lightning, if you avoid taking your position near tall trees, spires, or other elevated objects.

Q. *What is a* LIGHTNING-CONDUCTOR?

A. A metal rod fixed in the earth, running up the whole height of a building, and rising in a point above it.

Q. *What metal is the best for this purpose?*

A. Stout copper wire.

Q. *Why is* COPPER *wire better than iron?*

A. 1st—Because copper is a better conductor than iron:

2ndly—It is not so easily fused or melted: and

3rdly—It is not so much injured by weather.

Q. *What is the* USE *of a lightning-conductor?*

A. As metal wire is a most excellent conductor, the lightning (which makes choice of the *best conductors)* would run down the *metal wire*, rather than the walls of the building.

Q. *How* FAR *will the beneficial influence of a lightning-conductor extend?*

A. It will protect a space all round, 4 times the length of that part of the rod which *rises above the building.*

Q. *Give me an example.*

A. If the rod rise 2 feet above the house, it will protect the building for (at least) 8 feet all round.

Q. *Why are not lightning-conductors more generally used?*

A. Because lightning-conductors are often productive of more harm than good.

Q. *How can lightning-conductors be productive of* HARM?

A. If the rod be *broken* by weather or accident, the electric fluid (being obstructed in its path) will damage the building.

Q. *Is there any* OTHER *evil to be apprehended from a lightning rod?*

A. Yes; if the rod be not big enough to conduct the *whole* current to the earth, the lightning will *fuse* the metal, and injure the building.

It should be (at least) *one inch* in diameter.

Q. *How does* LIGHTNING *sometimes* KNOCK DOWN HOUSES *and churches?*

A. The steeple, or chimney is first struck; the lightning then darts to the iron bars and cramps employed in the building; and (as it darts from bar to bar) shatters to atoms the bricks and stones, which oppose its progress.

Q. *Can you tell me how St. Bride's Church (London) was nearly destroyed by lightning, about* 100 *years ago?*

A. The lightning first struck the metal vane, and ran down the rod; it then darted to the iron cramps, employed to support the building; and (as it flew from bar to bar) smashed the stones of the church, which lay between.

Q. *Why did the lightning fly about from place to place, and not pass down in a straight course?*

A. Because it always takes in its course the *best conductors;* and will fly both right and left, in order to reach them.

Q. *Why does* LIGHTNING *turn* MILK SOUR?

A. Lightning causes the gases of the air (through which it passes) to *combine,* and thus produces a poison, called *nitric acid;* some small portion of which, mixing with the milk, turns it sour.*

N. B. Sometimes, the mere *heat* of the air, during the storm, turns milk sour.

(* The air is composed of two gases, called oxygen and nitrogen, *mixed* together, but *not combined.* Oxygen *combined* with nitrogen, produces five deadly poisons, viz.—nitrous oxide, nitric oxide, hyponitrous acid, nitrous acid, and nitric acid, according to the proportion of each gas in the combination.)

Q. *What is the difference between* COMBINING *and* MIXING?

A. When different ingredients mingle *without undergoing any chemical change,* they are said to be *mixed;* but when the natural properties of each are *altered by the union,* then those ingredients are said to be *combined.*

Q. *Give me an example.*

A. If different coloured sands be shaken together in a bottle, the various grains will *mix* together, but not combine: but if water be poured on quick lime, the water will *combine* with the lime, and not mix with it.

Q. *Why are the different grains of sand said to be* MIXED, *when they are shaken together?*

A. Because they are mingled together, but the property of each grain remains the *same as it was before.*

Q. *Why is water poured on lime said to* COMBINE *with it?*

A. Because the properties of each are *altered* by the mixture: the lime

alters the character of the water, and the water of the lime.

Q. *Do oxygen and nitrogen* COMBINE, *or only* MIX *together, in common atmospheric air?*

A. They only *mix* together, as grains of sand would do, when shaken in a bottle. When oxygen and nitrogen *combine,* they do not constitute *air,* but acid *poisons.*

See note on p. 25.

Q. *Why does* LIGHTNING *turn* BEER SOUR, *although contained in a close cask?*

A. If the beer be *new,* and the process of fermentation not complete, lightning will so *accelerate* the process, as to turn the liquor sour.

Q. *Why is* NOT *old beer and strong* PORTER *made* SOUR *by lightning?*

A. Because the *fermentation is complete* already; and, therefore, is not affected by electrical influence.

Q. *Why is* METAL *sometimes* FUSED *by lightning?*

A. Because the dimension of the metal is *too small* to afford a path for the electric current.

Q. *Why does* LIGHTNING PURIFY *the* AIR?

A. For two reasons: 1st—Because the oxygen and nitrogen of the air *combine,** and produce "nitric acid:"

2ndly—Because the agitation of the storm *stirs up the air.*

Q. *How does the production of nitric acid* PURIFY *the air?*

A. Nitric acid acts very powerfully in *destroying exhalations,* arising from putrid vegetable and animal matters.

Q. *Why is* LIGHTNING *more common in* SUMMER *and* AUTUMN *than in spring and winter?*

A. The heat of summer and autumn produces *great evaporation;* and the conversion of *water to vapour* always develops *electricity.*

Q. *Why does a* THUNDER-STORM *generally follow very* DRY *weather?*

A. Because *dry air* (being a non-conductor) will not relieve the clouds of their electricity; so the fluid accumulates, till the clouds are discharged in a storm.

* The oxygen and nitrogen are not *combined,* but simply *mixed* in the ordinary air; but the lightning causes the mixed elements to *combine.* (See note on p. 25.)

Q. *Why does a* THUNDER-STORM *rarely succeed* WET *weather?*

A. Because moist air or falling rain (being a conductor) carries down the electric fluid gradually and silently to the earth.

Q. *What is the general* DIRECTION *of a* THUNDER-STORM?

A. Either from east to west; or from north to south:

Q. *Why is* ELECTRICITY *excited by* FRICTION?

A. Electricity, like heat, exists in *all* matter; but is often in a *latent state:* friction *disturbs* it, and brings it into active operation.

See p. 33.

Q. *Why is a* TREE *sometimes* SCORCHED *by lightning, as if it had been set on fire?*

A. Lightning scorches it by its own *positive heat,* just the same as fire would.

Q. *Why is the* BARK *of a* TREE *often ripped quite off by a flash of lightning?*

A. Because the latent heat of the tree is so rapidly developed by the electric fluid running down it, that it forces away the bark of the tree in its impetuosity to escape.

Some part of this effect is probably due to the simple *mechanical force* of the lightning.

Q. *Why are* BOUGHS *of* TREES *broken off by lightning?*

A. The *mechanical force* of lightning is very great; and as the boughs of a tree are imperfect conductors, they will often be broken off by this mechanical force.

Q. *Why is an electric shock felt* MOST *at the* ELBOW JOINT?

A. Because the path of the fluid is *obstructed by the joint:* and the shock felt at the elbow is caused by the fluid *leaping from one bone to another.*

Q. *Is electricity accompanied with any* ODOUR?

A. Yes: occasionally a strong *sulphurous* odour has been observed during a thunder-storm.

Q. *Does not electricity sometimes give a peculiar* TINGE *to objects around?*

A. Yes: and this peculiar colour, produced by electricity, is called "azure."

Q. *What are* FUL'GURITES?

A. Fulgurites are hollow tubes produced in sandy soils by the action of lightning.

Q. *How does lightning produce fulgurites?*

A. It enters the earth, and fuses the

flinty matter of the soil into a vitreous (or glassy) substance, which is called a fulgurite.

Q. *Does not lightning sometimes affect the character of* IRON *and* STEEL?

A. Yes; bars of iron and steel are sometimes rendered *magnetic* by lightning.

Q. *Give me an instance of the magnetic effects of lightning.*

A. Sometimes it will *reverse* the magnetic needles of the electric telegraph, and sometimes *destroy* their magnetism altogether.

Q. *What is meant by the magnetic needles being* REVERSED?

A. That part of the needle which ought to point towards the *north*, is made to point towards the *south;* and that part which ought to point south, is made to point towards the north.

Q. How *does lightning act upon the magnetic needles of the electric telegraph?*

A. The electric fluid is conveyed along the *conducting wires* to the telegraphic needles.

CHAPTER III.

Q. *What is the* THIRD *chief source of heat?*

A. CHEMICAL ACTION.

Q. *What is meant by chemical action being the source of heat?*

A. Many things, when their chemical constitution is changed, (either by the abstraction of some of their gases, or by the combination of others not before united,) evolve *heat*, while the change is going on.

Q. *Explain by illustration what you mean.*

A. Water is cold, and sulphuric acid is cold; but if these two *cold* liquids be mixed together, they will produce *intense heat*.

Q. *Why does* COLD WATER, *poured on* LIME, *make it intensely* HOT?

A. The heat is evolved by the *chemical action*, produced by the cold water combining with the lime.

N.B. Heat is always *evolved* when a fluid is converted into a *solid* form. Heat is always *absorbed* when a solid is changed into a *liquid* state. As the water is changed from its liquid form when it is taken up by the lime, therefore, heat is given off.

Q. *Where does the heat come from?*

A. It was in the water and lime, before; but was in a *latent state*.

Q. *Was there heat in the cold water and lime, before they were mixed together?*

A. Yes. *All* bodies contain heat; the coldest ice, as well as the hottest fire.

Q. *Is there* HEAT *even in* ICE?

A. Yes; but it is *latent*, (i. e. not perceptible to our senses).

Latent, from the Latin word, Lateo, (to lie hid.)

Q. *How do you* KNOW *there is heat, if you cannot* PERCEIVE *it?*

A. Thus:—Ice is 32° by the thermometer; but if ice be melted over a fire, (though 140° of heat are absorbed by the process,) it will feel no *hotter* than before.

(i. e. it will be only 32°, and not 172°).*

Q. *What becomes of the* 140° *which went into the ice to melt it?*

A. It is hidden in the water; or (to speak more scientifically) it is stored up in a *latent state.*

Q. *How* MUCH *heat may be thus secreted or made latent?*

A. *All* things contain a vast quantity of latent heat; but as much as 1140° of heat may remain latent in *water.*

* 32°, i. e. 32 degrees; 140°, i. e. 140 degrees, &c.

Q. *How can* 1140° *of heat be added to water, without being perceptible to our feelings?*

A. 1st—140° of heat are hidden in the water, when *ice is melted* by the sun or fire.

2ndly—1000° more of heat are secreted, when water is converted into *steam*. Thus, before *ice* is converted into steam, 1140° of heat become *latent*.*

Q. *Can we be made to* FEEL *the heat of* ICE *or snow?*

A. Yes. Into a pint of snow put half as much salt; then plunge your hand into the liquid; and it will feel so intensely cold, that the snow itself will seem *warm* in comparison to it.

Q. *Is* SALT *and* SNOW *really* COLDER *than snow?*

A. Yes, many degrees; and by dipping your hand into the mixture *first*, and into snow *afterwards*, the snow will seem to be comparatively warm.

* One pint of boiling water, (212° according to the thermometer,) will make 1800 pints of steam; but the steam is no hotter to the touch than boiling water, both are 212°; therefore, when water is converted into steam, 1000° of heat become latent. Hence, before ice is converted to steam, it must contain 1140° of latent heat.

Q. *What is* FIR
E?

A. Heat and light produced by the combustion of inflammable substances.

Q. *How is* HEAT *evolved by combustion?*

A. By *chemical action*;—as latent heat is liberated when water is poured upon lime.

See page 32.

Q. *What chemical action takes place in combustion?*

A. The elements of the fuel combine with the oxygen of the air.

Q. *What are the elements of* FUEL?

A. As bread is a compound of flour, yeast, and salt; so fuel is a compound of hydrogen and carbon.

Q. *What are the* ELEMENTS *of atmospheric* AIR?

A. The air is a compound of oxygen and nitrogen *mixed* together; in the proportion of four gallons of nitrogen to one of oxygen.

Q. *What is* CARBON?

A. The solid part of fuel. It abounds also in all animal bodies, earths, and in some minerals.



Q. *Mention some different* SP CIES *of* CARBON

A. Common charcoal, lamp-black, coke, black lead, and the diamond, are all varieties of carbon.

Q. *What is* HYDROGEN?

A. An inflammable gas. The gas used in our streets is only the hydrogen gas *driven out of coals by heat.*

Q. *What are the peculiar characteristics of hydrogen gas?*

A. Though this gas *itself* will burn, yet a candle will *not* burn when immersed in it; nor can an animal live in it. Hydrogen gas is the lightest of all known substances.*

Q. *What is* OXYGEN?

A. A gas, much heavier than hydro-

* Hydrogen gas may be made thus:—Put some pieces of zinc or iron filings into a glass: pour over them a little sulphuric acid (vitriol), diluted with twice the quantity of water; then cover the glass over for a few minutes, and hydrogen gas will be given off.

EXP. If a flame be put into the glass, an EXPLOSION will be made.

If the experiment be tried in a phial, which has a piece of tobacco-pipe run through the cork, and a light held a few moments to the top of the pipe, a FLAME will be made.

If a balloon be held over the phial, (so that the gas can inflate it,) the balloon will ascend in a very few minutes.

gen; it gives brilliancy to flame, and is essential to animal life.*

+ Oxygen gas is much more troublesome to make than hydrogen. The *cheapest* plan is to put a few ounces of manganese (called the black oxide of manganese) into an iron bottle, furnished with a bent tube; set the bottle on a fire till it becomes red hot, and put the end of the tube into a pan of water. In a few minutes, bubbles will rise through the water; these bubbles are oxygen gas.

These bubbles may be collected thus:—Fill a common bottle with water; hold it topsy-turvy over the bubbles which rise through the pan, but be sure the mouth of the bottle be held *in the water.* As the bubbles rise into the bottle, the water will run out; and when all the water has run out, the bottle is full of gas. Cork the bottle while the *mouth remains under water;* set the bottle on its base; cover the cork with lard or wax, and the gas will keep till it be wanted.

N.B. The *quickest* way of making oxygen gas, is to rub together in a mortar half an ounce of oxide of copper, and half an ounce of chlorate of potassa. Put the mixture into a common oil flask, furnished with a cork which has a bent tube thrust through it. Heat the bottom of the flask over a candle or lamp; and when the mixture is red hot, oxygen gas will be given off. Note—the tube must be immersed in a pan of water, and the gas collected as before.

(Chlorate of potassa may be bought at any chemist's; and oxide of copper may be procured by heating a sheet of copper red hot, and when cool, striking it with a hammer; the scales that peel off, are oxide of copper.)

Exp. Put a piece of red hot charcoal (fixed to a bit of wire) into your bottle of oxygen gas; and it will throw out most dazzling sparks of light.

Blow a candle out; and while the wick is still red, hold the candle (by a piece of wire) in the bottle of oxygen gas; the wick will instantly ignite, and burn brilliantly.

(Burning sulphur emits a *blue* flame, when immersed in oxygen gas.)

Q. *What is* NITROGEN?

A. Nitrogen is another invisible gas. It *will not* burn; and an animal cannot live in it: it abounds in animal and vegetable substances, and is the chief ingredient of the common air.*

4 parts of common air out of every 5 are nitrogen gas.

Q. *Why is there so* MUCH *nitrogen in the air?*

A. In order to *dilute* the oxygen. If the oxygen were not thus diluted, fires would burn out, and life be exhausted, too quickly.

Q. *What three elements are necessary to produce* COMBUSTION?

A. Hydrogen gas, carbon, and oxygen gas; the two former in the *fuel*, and the last in the *air* which surrounds the fuel.

Q. *What causes the combustion of the fuel?*

A. The hydrogen gas of the fuel

* Nitrogen gas may easily be obtained thus:—Put a piece of burning phosphorus on a little stand, in a plate of water; and cover a bell glass over. (Be sure the edge of the glass stands *in the water.*) In a few minutes the *oxygen* of the air will be taken up by the burning phosphorus; and the nitrogen alone will be left in the bell glass.

(N. B. The white fume, which will arise and be absorbed by the water in this experiment, is phosphoric acid; i. e. phosphorus combined with oxygen of the air.)

(being set free and excited by a light), *unites* with the *oxygen of the air* and makes a yellow flame: this flame heats the *carbon of the fuel,* which (also uniting with the oxygen of the air), produces *carbonic acid gas.*

Q. *What is* CARBONIC ACID GAS?

A. Only carbon (or charcoal) combined with oxygen gas.

Q. *Why does* FIRE *produce* HEAT?

A. Because it liberates *latent heat* from the air and fuel.

Q. *What* CHEMICAL CHANGES *in air and fuel are produced by* COMBUSTION?

A. 1st—*Some* of the oxygen of the air will combine with the *hydrogen* of the fuel, and condense into *water:* and

2ndly—Some will combine with the *carbon* of the fuel, and expand into *carbonic acid gas.*

Q. *Why is a* FIRE *(after it has been long burning)* RED HOT?

A. Because the surface of the coals is so thoroughly heated, that every part is undergoing a rapid union with the oxygen of the air.

Q. *In a* BLAZING *fire, why is the* UPPER *surface of the* COALS BLACK, *and the* LOWER *surface* RED?

A. Carbon (being very solid) requires a great degree of heat to make it unite with the oxygen of the air. In consequence of which, the hot *under* surface of coals is frequently *red* (from its union with oxygen), while the cold *upper* surface remains *black*.

Q. *Which burns the quicker, a* BLAZING *fire, or a* RED HOT *one?*

A. A *blazing* fire burns out the fuel quickest.

Q. *Why do* BLAZING COALS BURN QUICKER *than red hot ones?*

A. Because the inflammable *gases* of the fuel (which are then *escaping*) greatly assist the process of combustion.

Q. *Why do the coals of a* CLEAR BRIGHT *fire burn out slower, than blazing coals?*

A. Because most of the *inflammable gases,* and much of the *solid fuel,* have been consumed already; and the residue afford less food for combustion.

Q. *What is* SMOKE?

A. *Unconsumed* parts of fuel (principally carbon) separated from the solid mass, and carried up the chimney by the current of hot air.

Q. *Why is there* MORE SMOKE *when* COALS *are* FRESH *added, than when they are red hot?*

A. Carbon (being solid) requires a great degree of heat to make it unite with oxygen, (or, in other words, to bring it into a state of perfect combustion): when coals are fresh laid on, as *more carbon is separated* than can be *reduced to combustion,* much of it flies off in smoke.

Q. *Why is there so* LITTLE SMOKE *with a* RED HOT FIRE?

A. Because the *entire surface* of the coals is in a *state of combustion;* and as very little carbon remains unconsumed, there is but little smoke.

Q. *Why are there* DARK *and* BRIGHT SPOTS *in a* CLEAR *cinder* FIRE?

A. Because the *intensity* of the combustion is *greater in some parts* of the fire than it is in *others.*

Q. *Why is the intensity of the combustion so* UNEQUAL?

A. Because the air flies to the fire in various and unequal currents.

Q. *Why do we see all sorts of* GROTESQUE FIGURES *in hot* COALS?

A. Because the *intensity* of combustion is so *unequal*, (owing to the gusty manner in which the air flies to the fuel); and the various shades of red, yellow, and white heat (mingling with the black of the unburnt coal), produce strange and fanciful resemblances.

Q. *Why does* PAPER BURN *more readily than wood?*

A. Because it is of a *more fragile texture;* and, therefore, its component parts are more easily heated.

Q. *Why does* WOOD BURN *more readily than coal?*

A. Because it is not so *solid;* and, therefore, its elemental parts are more easily separated, and made hot.

Q. *When a* FIRE *is* LIGHTED, *why is* PAPER *laid at the* BOTTOM, *against the grate?*

A. Because paper (in consequence

of its fragile texture) very readily catches fire.

Q. *Why is* WOOD *laid on the top of the paper?*

A. Because wood (being more *substantial*) *burns longer* than paper; and, therefore, affords a *longer contact of flame* to heat the coals.

Q. *Why would not paper do* WITHOUT *wood?*

A. Because paper burns out so *rapidly*, that it would not afford sufficient *contact of flame* to heat the coals to combustion.

Q. *Why will not wood do* WITHOUT *shavings, straw, or paper?*

A. Because wood is too *substantial* to be heated into combustion by the flame issuing from a mere *match.*

Q. *Why would not the paper do as well, if placed on the* TOP *of the coals?*

A. Because every blaze *tends upwards;* if, therefore, the paper were placed on the *top* of the fire, its blaze would afford *no contact of flame* to the fuel lying *below.*

Q. *Why should* COAL *be placed* ABOVE *the wood?*

A. Because otherwise, the *flame* of the fuel would not rise *through the coal* to heat it.

Q. *Why is a* FIRE KINDLED *at the* LOWEST BAR *of a grate?*

A. That the flame may *ascend through the fuel,* to heat it. If the fire were kindled from the *top,* the flame would *not come into contact* with the fuel piled below.

Q. *Why does* COAL *make such* EXCELLENT FUEL?

A. Because it contains a large amount of *carbon* and *hydrogen gas* in a very compact and convenient form.

Q. *Why will* CINDERS *become* RED HOT *quicker than* COALS?

A. Because (being *more porous* and *less solid*) they are sooner reduced to a state of combustion.

Q. *Why will not* IRON CINDERS *burn?*

A. Iron cinders are *cinders saturated with oxygen;* in consequence of which, they can imbibe *no more oxygen,* and are unfit for fuel.

Q. *Why are* CINDERS *lighter than* COALS?

A. Because they are full of little holes; from which vapour, gases, and other volatile parts, have been driven off by *previous combustion.*

Q. *Why will not* STONES *do for fuel, as well as* COALS?

A. Because they contain no *hydrogen,* and little or no *carbon.*

Q. *Why will not* WET KINDLING *light a fire?*

A. 1st—Because the moisture of the wet kindling prevents the *oxygen of the air from getting to the fuel;* and

2ndly—The heat of the fire is perpetually *drawn off,* by the conversion of *water* into *steam.*

Q. *Why does* DRY *wood burn* BETTER *than* GREEN?

A. 1st—Because no heat is *carried away* by the conversion of *water into steam;* and

2ndly—The pores of dry wood being *filled with air,* supply the fire with oxygen.

Q. *Why do* TWO *pieces of* WOOD *burn* BETTER *than* ONE?

A. 1st—Because they help to en-

tangle the *heat of the passing smoke,* and *throw it on the fuel:* and

2ndly—The air, impinging against the pieces of wood, is thrown upon the fire in a kind of *eddy* or draught.

Q. *Why does* SALT CRACKLE, *when thrown into a* FIRE?

A. Salt contains *water;* and the *crackling* of the salt is owing to the sudden *conversion of the water into steam.*

Q. *Why will not wood or paper burn, if steeped in a solution of* POTASH, *phosphate of* LIME, *or* AMMONIA *(hartshorn)?*

A. Because any "al'kali" (such as potash) will *arrest the hydrogen* (as it escapes from the fuel), and prevent its *combination* with the *oxygen of air.*

Q. *What is an al'kali?*

A. The con'verse of an *acid;* as *bitter* is the con'verse of *sweet,* or *insipid* the con'verse of *pungent.*

Q. *Why does a* JET *of* FLAME *sometimes burst into the room* THROUGH THE BARS OF A STOVE?

A. Because the iron bars conduct heat to the *interior of some lump of coal;* and its volatile gas (bursting through

the weakest part) is kindled by the glowing coals over which it passes.

Q. *Why is this* JET *sometimes of a* GREENISH YELLOW *colour?*

A. When a lump of coal lies *over the hot bars*, or the coals below it are not *red hot*, some of the gas *escapes unburnt*, and is of a greenish colour.

Q. *Why does the gas escape* UNBURNT?

A. Because neither the *bars* nor *coals* (over which it passes) are *red-hot*.

Q. *Why does a* BLUISH FLAME *sometimes flicker on the surface of hot cinders?*

A. Because gas from the hot coals *at the bottom of the grate* mixing with the *carbon of the coals above*, produce an inflammable gas (called carbonic oxide), which burns with a blue flame.

Q. *Why is the* FLAME *of a good fire* YELLOW?

A. Because both the hydrogen and carbon of the fuel are in a state of *perfect combustion*. It is the *white heat of the carbon*, which gives the pale yellow tinge to the flaming hydrogen.

Q. *What is* LIGHT?

A. Rapid *undulations* of a fluid called *ether*, striking on the eye.

Q. *How does* COMBUSTION *make these undulations of* LIGHT?

A. The atoms of matter (set in motion by heat) *striking against* this ether, produce *undulations* in it; as a *stone* thrown into a stream, produces undulations in the *water*.

Q. *How can* UNDULATIONS *of ether produce* LIGHT?

A. As *sound* is produced by *undulations of air* striking on the *ear*, so *light* is produced by undulations of *ether* striking on the *eye*.

Q. *What is* ETHER?

A. A very subtile fluid, which pervades and surrounds *every thing we see*.

N. B. This theory of LIGHT is not altogether satisfactory; but has been retained as the most plausible hitherto projected.

Q. *Does* HEAT ALWAYS *produce* LIGHT?

A. No: the heat of a stack of hay, or reeking dunghill, though very *great* is not sufficient to produce *light*.

Q. *Why is a* YELLOW FLAME *brighter than a* RED HOT COAL?

A. Because *yellow rays* produce the greatest amount of *light;* though *red rays* produce the greatest amount of *heat*.

Q. *Why is the* LIGHT *of a fire* MORE INTENSE *sometimes than at others?*

A. The *intensity* of fire-light depends upon the *whiteness* to which the carbon is reduced by combustion. If the carbon be *white hot,* its *combustion is perfect,* and the light intense; if not, the light is obscured by *smoke.*

Q. *Why will not* CINDERS BLAZE, *as well as* FRESH *coals?*

A. The *flame* of coals is made chiefly by *hydrogen gas.* As soon as this gas has been consumed, the hot cinders produce only an *invisible* gas, called carbonic acid.

Q. *Where does the hydrogen gas of a fire come from?*

A. All fuel is *composed* of carbon and hydrogen gas, which are separated from each other by the process by combustion. (see p. 35).

Q. *Why does not a* FIRE BLAZE *on a* FROSTY NIGHT, *so long as it does upon another night?*

A. 1st—Because air *condensed* by the cold contains more *oxygen* than the same quantity of warmer air; and

2ndly—Being very cold it rushes to the fire more rapidly; in consequence of which, the inflammable gas of the coals is more quickly consumed.

Q. *Why does a* FIRE *burn* CLEAREST *on a* FROSTY *night?*

A. Because the volatile gases are more quickly consumed; and the solid carbon *plentifully supplied with oxygen* from the air, to make it burn brightly and intensely.

Q. *Why does a* FIRE *burn more intensely in* WINTER, *than in* SUMMER?

A. Because the air is *colder* in winter than in summer.

Q. *Why does the* COLDNESS *of the air increase the* HEAT *of a fire?*

A. For two reasons: 1st—Because cold air is more *condensed* than hot: and

2ndly—Because it rushes to the fire more *quickly;* in consequence of which, the fire is supplied more abundantly with *oxygen.*

Q. *Why does the* SUN, *shining on a* FIRE, *make it* DULL, *and often put it out?*

A. Because the sun-shine rarefies

the air, so that it *flows more slowly to the fire;* and even that which *reaches* the fire, affords *less nourishment.*

Sun-shine produces also some *chemical effect* upon the air or fuel detrimental to combustion.

Q. *Why does the air flow to the fire more* TARDILY *for being* RAREFIED?

A. Because the greater the *contrast* (between the *external air* and that *which has been heated by the fire)* the more *rapid* will be the current of air towards that fire.

Q. *Why does rarefied air afford* LESS NOURISHMENT *to fire than cold air?*

A. Because rarefied air contains less *oxygen* than the same quantity of condensed air.

Inasmuch as the same quantity of oxygen is diffused over a larger volume of air.

Q. *Why does a* FIRE *burn more fiercely in the* OPEN AIR?

A. 1st—Because the *air out-of-doors* is more *dense* than the air in-doors; and

2ndly—It has freer *access* to the fire.

Q. *Why is the air out-of-doors more* DENSE, *than that in-doors?*

A. Because it has freer circulation;

and as soon as any portion has been *rarefied*, it instantly escapes, and is supplied by *colder currents*.

Q. *Why does not a* FIRE *burn so freely in a* THAW, *as in a* FROST?

A. Because (being laden with *vapour*) it both *moves too slowly*, and is too much *rarefied*, to nourish the fire.

Q. *Why does a* FIRE *burn so fiercely in* WINDY *weather?*

A. In windy weather the *air is rapidly changed*, and affords plentiful nourishment to the fire.

Q. *Why do a pair of* BELLOWS *get a fire up?*

A. A pair of bellows *drives the air more rapidly to the fire;* and the plentiful supply of oxygen soon makes the fire burn intensely.

Q. *Why is the flame of a* CANDLE EXTINGUISHED *when blown by the breath, and not made more intense, like a fire?*

A. As the flame of a candle is confined to a *very small wick*, it is *severed* from it by the breath; and (being unsupported) *must go out.*

Q. *Why is a* SMOULDERING WICK *sometimes* REKINDLED *by blowing it?*

A. The breath carries the air to it with *great rapidity;* and the oxygen of the air kindles the *red hot wick,* as it kindles charred wood.

Q. *Why is not the red hot wick kindled by the air* AROUND *it, without* BLOWING *it?*

A. Because oxygen is not supplied with sufficient freedom, unless it be *blown* to the wick.

Q. *When is this experiment most likely to succeed?*

A. In *frosty* weather; because the air contains more oxygen then, *being condensed by the cold.*

Q. *Why does a* POKER, LAID ACROSS *a dull* FIRE, *revive it?*

A. For two reasons: 1st—Because the poker *concentrates the heat,* and therefore increases it; and

2ndly—As a narrow aperture is made between the poker and the coals, the air is arrested, and a *draught* created.

See also the question at the foot of page 45.

Q. *Why are* STOVES *fixed on the* FLOOR *of a room?*

A. In order that the air *on the lower part of the room* may be heated by the fire.

Q. *Would not the air of the lower part of a room be heated equally well, if the stoves were fixed higher up?*

A. No; the heat of a fire has a very little effect upon the air *below the level of the grate;* and, therefore, every grate should be as *near to the floor* as possible.

Q. *Why are our* FEET *very frequently* COLD, *when we sit close by a good fire?*

A. As the fire consumes the air which passes over it, *cold air* rushes through the crevices of the doors and windows *along the bottom of the room* to supply the deficiency; and these currents of cold air, *rushing constantly over our feet,* deprive them of their warmth.

Q. *If a piece of* PAPER *be laid* FLAT *on a clear fire. it will* NOT BLAZE, *but* CHAR. *Why so?*

A. The carbon of a clear fire, being sufficiently hot to unite with the oxygen

of the air, *produces carbonic acid gas*, which soon envelops the paper laid flat upon the cinders: but carbonic acid gas will not *blaze*.

Q. *If you* BLOW *the paper, it will* BLAZE *immediately. Why so?*

A. By blowing, or opening a door suddenly, *the carbonic acid is dissipated*, and the paper fanned into flame.

Q. *Why does* WATER EXTINGUISH *a* FIRE?

A. 1st—Because the water *forms a coating* over the fuel, which keeps it from the air; and

2ndly—The conversion of *water into steam*, draws off the *heat* of the burning fuel.

Q. *Why does a* LITTLE WATER *make a fire* FIERCER, *while a* LARGER *quantity of water puts it* OUT?

A. Water is composed of *oxygen* and *hydrogen*; when, therefore, the fire can decompose the water into its simple elements, it serves for *fuel* to the flame.

Q. *How can* WATER *serve for* FUEL *to fire?*

A. The *hydrogen* of the water will burn with a *flame*; and the *oxygen* of the water increase the *intensity* of that flame.

Q. *If a house be on fire, is too* LITTLE *water worse than* NONE?

A. Certainly. Unless the water be supplied so plentifully as *to quench the fire* it will increase its *intensity*, like fuel.

Q. *When will water* EXTINGUISH FIRE?

A. When the supply is so rapid and abundant, that the fire cannot decompose it.

Q. *Does not a very* LITTLE *water* SLACKEN *the heat of fire?*

A. Yes, *till it is* decomposed; it then increases the *intensity* of fire, and acts like fuel.

Q. *Why does the* WICK *of a candle (when the flame has been blown out) very readily* CATCH FIRE?

A. Because the wick is already *hot*, and a very little *extra* heat will throw it into flame.

Q. *Why does the* EXTRA *heat revive the flame?*

A. Because it again liberates the *hydrogen* of the tallow, and ignites it.

Q. *Cannot* WOOD *be made to* BLAZE *without actual contact with fire?*

A. Yes; if a piece of wood be held *near* the fire for a little time it will blaze, even though it does not *touch* the fire.

Q. *Why will* WOOD BLAZE, *even if it does not touch the fire?*

A. The heat of the fire *drives out the hydrogen gas* of the wood; which is inflamed by contact with the red-hot coals.

Q. *Why will a* NEIGHBOUR'S HOUSE *sometimes* CATCH FIRE, *though no flame of the burning house ever touches it?*

A. The heat of the burning house sets at liberty *the hydrogen gas* of the neighbouring wood-work, which is ignited by the flames or red-hot bricks of the house on fire.

Q. *What is* COKE?

A. Coal freed from its volatile gases, by the action of artificial heat.

Q. *Why do* ARNOTT'S STOVES *sometimes* SMELL *so strongly of* SULPHUR?

A. Because coke contains sulphur; and, whenever the draught is not rapid enough *to drive the sulphur up the flue,* it is emitted into the room.

Q. *What is meant by* SPONTANEOUS COMBUSTION?

A. Combustion produced without the application of *flame.*

Q. *Give an example of spontaneous combustion.*

A. Coals stowed in the hole of a vessel, and goods packed in a warehouse, will often catch fire of *themselves*,—especially such goods as cotton, flax, hemp, rags, &c.

Q. *Why do such* GOODS *sometimes* CATCH FIRE *of themselves?*

A. Because they are piled together in very *great masses* in a *damp* state or place.

Q. *Why does this produce spontaneous combustion?*

A. The damp produces *decay* or the decomposition of the goods, and the great heat of the piled-up mass makes the decaying goods *ferment.*

Q. *How does this* FERMENTATION *produce* COMBUSTION?

A. During fermentation, *carbonic acid gas* is given off by the goods,—a slow combustion ensues,—till at length the *whole pile* bursts into *flame.*

Q. *Why is the* HEAT *of a* LARGE MASS *of goods* GREATER *than that of a smaller quantity?*

A. Because the carbonic acid cannot

escape through the massive pile; and the products of decomposition being *confined,* hasten further changes.

Q. *Why do* HAY-STACKS *sometimes* CATCH FIRE *of themselves?*

A. Either because the hay was got up *damp,* or because rain has penetrated the stack.

Q. *Why will a* HAY-STACK CATCH FIRE *if the hay be damp?*

A. Damp hay soon *decays,* and undergoes a *state of fermentation;* during which, *carbonic acid gas* is given off, and the stack catches *fire.*

Q. *Why does roasted* COFFEE *sometimes* CATCH FIRE *spontaneously?*

A. The *heat* of coffee is greatly increased by being *roasted;* and the *carbon of the coffee* uniting with the *oxygen of the air,* produces *carbonic acid gas,* and bursts into *flame.*

Q. *Why do old* RAGS, *used for* CLEANING LAMPS *and* CANDLESTICKS, *sometimes set a* HOUSE *on* FIRE?

A. Because they very readily *ferment,*

and (during fermentation) throw off exceedingly inflammable gases.

(N. B. Lamp-black mixed with linseed oil is more liable to spontaneous combustion than anything that servants handle.)

CHAPTER IV.

SMOKE.

Q. *Why does* SMOKE ASCEND *the chimney?*

A. As the air of the room passes over the fire, it becomes *heated;* and (being thus made *lighter)* ascends the chimney, carrying the smoke with it.

Q. *What is* SMOKE?

A. Small particles of carbon, separated by combustion from the fuel, but not *consumed.*

Q. *Why do* SMOKE *and steam* CURL, *as they ascend?*

A. They are pushed round and round by the ascending and descending currents of air.

Q. *What are* BLACKS?

A. Smoke condensed by the air into flakes, which fall to the earth by their own weight.

Q. *Why are there* NO BLACKS *in the smoke of a* RAILWAY *engine?*

A. The smoke of a railway engine consists chiefly of *watery vapour,* which dissolves in air, as sugar does in water; but the smoke of a common chimney consists of small fragments of *unburnt fuel.*

The black deposit, which sometimes annoys the railway traveller, arises from water thrown through the chimney of the locomotive, and made dirty in its passage.

Q. *Why does a* "COPPER HOLE" DRAW *up more fiercely than an* OPEN *stove?*

A. Because the air, which supplies the copper hole, must pass *through the furnace;* and as it becomes exceedingly *heated,* rushes up the chimney with great violence.

Q. *What produces the* ROARING *noise made by a* COPPER-HOLE *fire?*

A. Air rushing rapidly through the crevices of the *iron door,* and up the *chimney flue.*

Q. *Why is the* ROAR LESS, *if the copper-hole* DOOR *be thrown* OPEN?

A. Because *fresh* air gets access to the fire *more easily;* and as the air is not so intensely heated, its motion is not so *violent.*

Q. *Why do some* CHIMNEYS SMOKE?

A. If fresh air is not admitted into a room, *as fast as it is consumed by the fire,* a current of air *will rush down the chimney* to *supply the deficiency,* and bring the smoke along with it.

Q. *What prevents air being supplied, as fast as it is consumed by the fire?*

A. Leather and curtains round the doors; sand-bags at the threshold and on the window-frames; and other contrivances to keep out the draught.

Q. *Why is it needful for cold fresh air to be so constantly supplied?*

A. If water be taken with a pail out of a river, *other* water will rush towards the hole, as soon as the pail is lifted out; and if air be taken from a room (as it is, when some of it goes up the chimney) *other air* will rush towards the void to fill it up.

Q. *Why will it come down the* CHIMNEY?

A. Because (if the doors and windows are all made *air-tight*) it can get into the room in no *other* way.

Q. *What is the best* REMEDY *in such a case?*

A. The *speediest* remedy is to open the door or window: but by far the *best* remedy, is to carry a small tube from the hearth into the external air.

Q. *Why is that the* BEST *remedy?*

A. Because the fire will be plentifully supplied with air by the tube: the doors and windows may all remain air-tight; and we may enjoy a warm fireside, without the inconvenience of draughts and cold feet.

Q. *Why is a* CHIMNEY *raised so high above the* ROOF?

A. If it were not so, it would smoke; as all funnels do, which are too short.

Q. *What is meant by the* FUNNEL *or* FLUE *of a chimney?*

A. That part of a chimney through which *the smoke passes,* is called the funnel or flue.

Q. *Why does a* CHIMNEY SMOKE, *if the funnel be very short?*

A. Because the *draught* of a short flue is *too slack* to carry the smoke up the chimney.

Q. *Why is the* DRAUGHT *of a* SHORT FLUE *more* SLACK *than that of a long one?*

A. For many reasons: 1st—*The fire is always dull and sluggish* if the chimney be too short:

2ndly—The smoke rolls *out* of the chimney, before it has acquired its *full velocity:* and

3rdly—The wind, rain, and air, have more influence over a *short* funnel than over a *long* one.

Q. *Why is the* FIRE *always* DULL *and sluggish, if the* CHIMNEY-FLUE *be very* SHORT?

A. Because the draught is so bad: and as the rarefied air *passes up the chimney very tardily, fresh air* flows as tardily *towards the fire*, to supply it with *oxygen.*

Q. *On what does the* INTENSITY *of fire depend?*

A. The *intensity* of fire is always in proportion to the *quantity of oxygen* with which it is supplied.

Q. *Why does not* SMOKE *acquire its full* VELOCITY *in a* SHORT *funnel?*

A. Because the *higher* smoke ascends, (provided the flue be clear and hot) the *faster* it goes: if, therefore, a *funnel be very short*, the smoke never acquires its full velocity.

Q. *Does the* DRAUGHT *of a chimney depend on the* SPEED *of the* SMOKE *through the flue?*

A. Yes. The more quickly *hot* air flies *up the chimney*, the more quickly *cold* air will rush *towards the fire* to supply the place; and, therefore, the *longer the flue*, the *greater the draught.*

Q. *Why is the* DRAUGHT *of a* LONG FLUE GREATER *than that of a short one?*

A Because the *higher* smoke ascends, the *faster* it goes; if, therefore, a funnel be *long*, the smoke acquires great *velocity*, and the *draught* is great.

Q. *If a* CHIMNEY *be* TOO SHORT, *and cannot be lengthened, what is the best* REMEDY *to prevent smoking?*

A. To *contract the opening of the chimney* contiguous to the stove.

Q. *Why will a* SMALLER OPENING *against the stove* PREVENT *the* SMOKING?

A. Because the air (being more *heated* by nearer contact with the fire) will rise through the chimney more rapidly: and this *increase* of *heat* will compensate for the *shortness* of the *flue*.

Q. *Why will a* ROOM SMOKE, *if there be* TWO FIRES *in it?*

A. Because the *fiercer* fire will exhaust the most air; and draw from the *smaller* one to supply its demand.

Q. *Why will a chimney* SMOKE, *if there be a* FIRE *in* TWO ROOMS *communicating with each other?*

A. Because, (whenever the *door* between the two rooms *is opened*), air will rush from the chimney of the *inferior* fire to supply the *other;* in consequence of which, *both* rooms will be filled with smoke.

Q. *What is the best* REMEDY *in this case?*

A. Let a tube be carried from the hearth of each stove into the external air; and then *each* fire will be so *well* supplied, that neither will need to borrow from the other.

Q. *Why do* VESTRY CHIMNEYS *so often* SMOKE?

A. Because the wind (striking against the steeple) *is reflected back;* and, rushing down the vestry chimney, forces the smoke *into the room.*

Q. WHAT WINDS *make vestry chimneys smoke?*

A. Those from the north-east or south-east: according to the position of the vestry.

Q. *Why will the* EASTERN *winds make* VESTRIES SMOKE, *more than those from the west?*

A. Because they *strike against the steeple,* and *bound back* to the vestry chimney: but *western* winds cannot rebound over the roof of a church.

N. B. The *steeple* of a church is always due *west,* and the *other* end of the church due *east;* if, therefore, a *western* wind were to rebound, it would rebound to the *west* (or *away from the church*), and not *towards* it.

Q. *Why does a* HOUSE *in a* VALLEY *very often* SMOKE?

A. Because the wind (striking against the surrounding hills) *bounds back again upon the chimney,* and destroys its draught.

Q. *What is the common* REMEDY *in both these cases?*

A. To fix a *cowl* on the chimney top, to turn like a weather-cock, and present its back to the wind.

Q. *Why will not a* COWL *always* PREVENT *a chimney* SMOKING?

A. If the wind be *strong*, it will keep the *opening* of the cowl *towards the steeple or hill*; and then the reflected wind will blow *into the cowl*, and *down the chimney*.

Q. *As a cowl is such a poor remedy, can any* OTHER *be devised?*

A. If the chimney flue can be carried *higher* than the steeple or hills, no wind can enter the flue.

Q. *If a chimney flue be carried up* HIGHER *than the steeple or hills, why cannot the wind enter it?*

A. Because the reflected wind would strike against the *sides* of the chimney-flue, and not pass over the *opening* at all.

Q. *In what* OTHER *cases will a* CHIMNEY SMOKE?

A. If both door and chimney be placed on *the same side of a room*, the chimney will often smoke.

Q. *Why will a* CHIMNEY SMOKE, *if the* DOOR *and* STOVE *are both on the* SAME SIDE?

A. Because (whenever the door is opened), a current of air will *blow into the chimney-place*, and drive the smoke into the room.

Q. *What* REMEDY *can be applied to this evil?*

A. The door must be set *opposite* to the chimney, or nearly so; and then the draught from the door *will blow the smoke up the chimney*, and not into the room.

Q. *Why will a* CHIMNEY SMOKE *if it* NEEDS SWEEPING?

A. Because the obstruction in the chimney (presented by the loose soot to the free passage of the smoke) *delays its current*, and prevents the draught.

Q. *Why will a* CHIMNEY SMOKE *if* OUT OF REPAIR?

A. 1st—Because the *loose mortar and bricks* obstruct the smoke: and

2ndly—The *cold air* (oozing through the chinks) *chills the air in the chimney*, and prevents its ascent.

Q. *Why will an* ARNOTT'S STOVE SMOKE, *if the joints of the flue do not fit air-tight?*

A. Because the *cold air* (which gets

through the joints) *chills the air in the flue,* and prevents its ascent.

Q. *Why does an old fashioned* FARM CHIMNEY-PLACE *so often smoke?*

A. Because the opening is so *very large,* that much of the air which goes up the chimney, *has never passed near the fire;* and this *cold* air (mixing with the hot), so *reduces its temperature,* that it ascends very slowly, and the draught is destroyed.

Q. *Why does a chimney smoke, if the* DRAUGHT *be* SLACK?

A. Because the current of air up the chimney is not powerful enough to *buoy up the smoke* through the flue.

Q. *If the opening of a chimney be* TOO LARGE, *what* REMEDY *can be applied?*

A. The chimney-place must be contracted.

Q. *Why will* CONTRACTING *the chimney-place* PREVENT *its* SMOKING?

A. Because the air will then pass *nearer the fire;* and (being *more heated)* fly faster up the chimney.

Q. *Why do almost all* CHIMNEYS SMOKE *in* GUSTY *weather?*

A. Because the column of smoke is suddenly chilled by the wind, and (being unable to ascend) rushes back into the room.

Q. *What is the use of a* CHIMNEY-POT *?*

A. When the opening of a chimney is too *large*, a chimney-pot will serve to increase the draught.

Q. *How does a* CHIMNEY-POT INCREASE *the* DRAUGHT *of a chimney?*

A. As the *same quantity* of hot air has to escape through a *smaller opening*, it must pass through more quickly.

Q. *Why do tin* BLOWERS *help to get a fire up?*

A. Because they compel the air to go *through* the fire, and not *over* it; in consequence of which, the fire is well supplied with oxygen, and the draught greatly increased.

Q. *Why does a tin* BLOWER INCREASE *the* DRAUGHT?

A. Because the air (by passing *through* the fire) is made much hotter, and ascends the chimney more rapidly.

Q. *Why is a fire better supplied with oxygen while the tin-blower hangs before it?*

A. Because the tin blower increases the draught; and the faster the *hot* air flies *up the chimney,* the faster *cold* air will rush *towards the* fire to supply it with oxygen.

Q. *Why does a parlour often* SMELL *disagreeably of* SOOT *in* SUMMER-TIME?

A. Because the air in the *chimney* (being *colder* than the air in the *parlour)* *descends into the room,* and leaves a disagreeable smell of soot behind.

Q. *Why are the* CEILINGS *of* PUBLIC OFFICES BLACK *and filthy?*

A. Because the heated air of the office buoys up the dust and fine soot; which (being unable to escape through the plaster) is deposited on the ceiling.

Q. *Why are* SOME *parts of the ceiling* BLACKER *and more filthy than others?*

A. As the air cannot penetrate the thick *joists* of the ceiling, *it passes by those parts,* and deposits its soot and dust on others more penetrable.

N.B. The site of this deposit of soot and dust is frequently determined by draughts and currents of air.

Q. *What is* CHARCOAL?

A. Wood which has been exposed to a red heat, till it has been deprived of all its gases and volatile parts.

Q. *Why is a* CHARCOAL FIRE *hotter than a wood fire?*

A. Because charcoal is very *pure* carbon; and as it is the *carbon* of fuel which produces the glowing heat of combustion, therefore, the *purer* the carbon the more intense will the heat of the fire be.

Q. *Why does charcoal* REMOVE *the* TAINT *of meat?*

A. Because it absorbs all putrescent effluvia, whether they arise from animal or vegetable matter.

Q. *Why is* WATER PURIFIED *by being filtered through charcoal?*

A. Charcoal absorbs the *impurities* of the water, and removes all disagreeable tastes and smells, whether they arise from animal or vegetable matter.

Q. *Why are water and wine* CASKS CHARRED *inside?*

A. Because *charring* the inside of the cask reduces it to a *kind of char-*

coal; and charcoal (by absorbing animal and vegetable impurities) keeps the liquor sweet and good.

Q. *Why does a piece of* BURNT BREAD *make impure* WATER *fit to drink?*

A. Because the surface of the bread (which is reduced to *charcoal* by being burnt) absorbs *the impurities of the water,* and makes it palatable.

Q. *Why should the* TOAST *and* WATER, *placed by the side of the sick, be made of* BURNT BREAD?

A. Because the surface of the bread (*reduced to charcoal* by being burnt) prevents the water from being affected by the impurities of the sick room.

Q. *Why should sick persons eat* DRY TOAST, *rather than bread and butter?*

A. Because the charcoal surface of the dry toast helps to absorb the acids and impurities of a sick stomach.

Q. *Why are* TIMBERS, *which are to be exposed to damp,* CHARRED?

A. Because *charcoal undergoes no change* by exposure to air and water; in consequence of which, timber will resist weather *much longer* after it has been charred.

CHAPTER V.

LAMPS AND CANDLES.

Q. *Of what are* OIL, TALLOW, *and* WAX *composed?*

A. Principally of carbon and hydrogen gas. The *solid* part is carbon, the *volatile* part is hydrogen gas.

Q. *What is* CARBON?

A. A solid substance, generally of a black colour; well known under the forms of charcoal, lamp-black, coke, &c.

Q. *What is* HYDROGEN GAS?

A. The principal ingredient of water. It is well known in the form of common *coal gas:* it burns so readily that it used to be called "inflammable air."*

Q. *Why does a* CANDLE BURN, *when lighted?*

A. The heat of the lighted wick *decomposes the tallow* into its elementary

* To make hydrogen gas, see p. 30.

parts of carbon and hydrogen; and the *hydrogen of the tallow,* combining with the *oxygen of the air*, produces *flame.*

Q. WHERE *is the tallow or wax of a candle decomposed?*

A. In the *wick.* The heat of the lighted wick first *melts* the tallow or wax, which rises (by capillary attraction) *up the wick,* and is rapidly decomposed by the heat of the flame.

Q. *What is capillary attraction?*

A. The power which very minute tubes possess, of causing a liquid to rise in them above its level.

"Capillary," from the Latin word "capillaris" (*like a hair*), the tubes referred to are almost as fine and delicate as a hair.

Water ascends through a lump of sugar, or piece of sponge, by capillary attraction; and sap rises from the root to the topmost branch of a tall tree by the same influence. N. B. The smaller a tube, the higher will a liquid be attracted by it.

Q. *Why is the* FLAME *of a candle* HOT?

A. Because the flame liberates *latent heat* from the air and tallow.

Q. *How is* LATENT HEAT *liberated by the flame of a* CANDLE?

A. When the elements of the tallow

combine with the *oxygen* of the air, latent heat is liberated by the chemical changes.

Q. *Why does the flame of a* CANDLE *produce* LIGHT?

A. Because the chemical changes made by combustion, excite *undulations of ether*, which (striking the eye) produce light. *

* See p. 48.

Q. *Why is the* FLAME *of a* CANDLE YELLOW?

A. It is *not* so altogether: only the *outer* coat of the flame is yellow; the *lower* part is *violet;* and the *inside* of the flame *hollow*.

Q. *Why is the outside of the flame* YELLOW?

A. Because the *carbon of the tallow* (being in a state of *perfect combustion*) is made white-hot.

Q. *Why is the* BOTTOM *part of the flame* PURPLE?

A. Because it is *overladen with hydrogen* (raised from the tallow by the burning wick); and this *half-burnt gas* gives a *purple* tinge to the flame.

Q. *Why is the* INSIDE *of the flame of a candle* HOLLOW?

A. Because it is *filled with vapour*, raised from the candle by the *heat of the wick*, and not yet reduced to a state of combustion.

Q. *Describe the different parts of the* FLAME *of a common* CANDLE.

A. The flame consists of *three cones.* The innermost cone is hollow; the intermediate cone of a dingy purple hue; and the outside cone is yellow.

Q. *Why is the intermediate cone of a flame* PURPLE, *as well as the* BOTTOM *of the flame?*

A. Because the gases are not in a state of *perfect combustion;* but contain an *excess of hydrogen*, which gives it the purple tinge.

Q. *Why is not the* MIDDLE *cone in a state of perfect combustion, as well as the* OUTER *cone?*

A. Because the outer cone *prevents the oxygen of the air* from getting to it; and without the free access of oxygen gas, there is no such thing as complete combustion.

Q. *Why does the* FLAME *of a candle point* UPWARDS?

A. Because it *heats the surrounding*

air, which (being hot) *rapidly ascends,* and drives the flame upwards at the same time.

Q. *Why is the* FLAME *of a candle* POINTED *at the top, like a cone?*

A. Because the *upper* part of a flame is more *volatile* than the lower; and as it affords *less resistance to the air,* is reduced to a mere point.

Q. *Why are the* LOWER *parts of a flame less* VOLATILE *than the upper?*

A. Because they are laden with unconsumed gas and watery vapour; which present considerable resistance to the air.

Q. *Why is the* FLAME *of a candle* BLOWN OUT *by a puff of breath?*

A. Because it is *severed from the wick,* and goes out for want of support.

Q. *Why does the* FLAME *of a candle make a* GLASS *(which is held over it)* DAMP?

A. Because a "watery vapour" is made by the combination of the *hydrogen of the tallow* with the *oxygen of the air,* which is condensed by the *cold glass* held above the flame.

Q. *Why does our hand, held* ABOVE *a candle, suffer from the heat of the flame so much more, than when it is placed* BELOW *the flame, or on* ONE SIDE *of it?*

A. Because the hot gases and air (in their ascent) *come in contact* with the hand placed *above* the flame: but when the hand is placed *below* the flame, or on *one side*, it only feels heat from *radiation.*

Radiation i. e. emission of rays.

Q *Why is a* RUSH LIGHT *extinguished more quickly, than a cotton-wicked candle?*

A. For two reasons: 1st—Because the *rush* is smooth and hard; in consequence of which, the flame is more easily severed from it: and

2ndly—A rush supplies *fewer combustible gases,* than the porous wick of a cotton candle.

Q. *Why is it more difficult to blow out a* COTTON *wick?*

A. 1st—Because the *cotton* wick is *quite full of small threads* or filaments, which help to *hold the flame on the wick,* like the roots of a tree: and

2ndly—A cotton wick (being very porous) supplies the flame with more combustible gases, than a hard rush.

Q. *Why is a* GAS FLAME *more easily extinguished when the jet is very slightly turned on, than when it is in full stream?*

A. Because there are fewer combustible gases in the small flame, than in the full blaze.

Q. *Why does an* EXTINGUISHER *put a candle out?*

A. Because the air in the extinguisher *is soon exhausted of its oxygen* by the flame: and when there is no *oxygen to support* the flame, *it* goes out.

The extinguisher acts *mechanically* also, by *nipping* the flame out.

Q. *Why does not a candle set fire to a* PIECE OF PAPER *twisted into an extinguisher, and used as such?*

A. 1st—Because the flame very soon *exhausts the little oxygen* contained in the paper extinguisher: and

2ndly—The flame invests the *inside of the paper extinguisher* with *carbonic acid gas,* which prevents it from blazing.

See also the note added to the last question.

Q. *Why is a* LONG WICK *never upright?*

A. Because it is bent by its own weight.

Q. *Why is a* LONG WICK *covered with an* EFFLORESCENCE *at the top?*

A. The knotty or flowery appearance of the top of a wick arises from an accumulation of particles *partly separated*, but still loosely hanging to the wick.

Q. *Why is not the* END *of a long wick* BURNT OFF, *as it hangs over the flame?*

A. Because the length of the wick so diminishes *the heat of the flame*, that it is not *hot* enough to burn it off.

Q. *Why do* PALMER'S METALLIC WICKS *never need* SNUFFING?

A. Because the wick is divided into two parts, each of which bends towards the outside of the flame, where the *end is intensely heated,* and *separated* from the wick by the current of air up the candle.

N.B. The small wire twisted in the wick greatly assists the process.

Q. *Why do common* CANDLES *require to be* SNUFFED?

A. Because the heat of the flame is *not sufficient to consume the wick;* and the *longer* the wick grows, the *less heat* the flame produces.

Q. *Why do* WAX CANDLES NEVER *need* SNUFFING?

A. Because the wick of *wax* candles is made *of very fine thread,* which the heat of the flame is sufficient to consume: The wick of *tallow* candles (on the other hand) is made *of coarse cotton,* which is too substantial to be consumed by the heat of the flame, and must be cut off by *snuffers.*

Q. *Why does a* PIN, *stuck in a* RUSH-LIGHT, EXTINGUISH *it?*

A. Because a *pin* (being a good conductor) *carries away the heat of the flame from the wick,* and prevents the combustion of the tallow.

Q. *What is the* SMOKE *of a* CANDLE?

A. Solid particles of carbon separated from the wick and tallow, but not consumed.

Q. *Why are* SOME *particles consumed and not* OTHERS?

A. The *combustion of the carbon* depends upon its *combining with the oxygen of the air:* Now, as the outer surface of the flame *prevents the access of air to the interior parts,* much of the carbon of those parts passes off in smoke.

Q. *Why do* LAMPS SMOKE?

A. Either because the *wick is cut unevenly,* or else because *it is turned up too high.*

Q. *Why does a* LAMP SMOKE, *when the* WICK *is cut* UNEVENLY?

A. 1st—Because the *points of the jagged edge* (being very easily separated from the wick) *load the flame with more carbon than it can consume:* and

2ndly—As the heat of the flame is *greatly diminished by these bits of wick,* it is unable to consume *even the usual quantity of smoke.*

Q. *Why does a* LAMP SMOKE, *when the* WICK *is turned up too* HIGH?

A. Because more carbon is separated from the wick, *than can be consumed by the flame.*

Q. *Why do not* "ARGAND BURNERS" *smoke?*

A. Because a current of air passes through the *middle of the flame;* in consequence of which, the carbon of the *interior* is consumed, as well as that *in the outer coating of the flame.*

Q. *Why does a* LAMP-GLASS DIMINISH *the* SMOKE *of a lamp?*

A. 1st—Because it increases the supply of *oxygen* to the flame by producing a draught; and

2ndly—It *concentrates* and *reflects the heat* of the flame; in consequence of which, the combustion of the carbon is more *perfect,* and very little escapes unconsumed.

CHAPTER VI.

ANIMAL HEAT.

Q. *What is the cause of* ANIMAL HEAT?

A. Animal heat is produced *by the combustion of hydrogen and carbon* in the capillary veins.

Q. *What are* CAPILLARY VEINS?

A. Veins *as small as hairs* running *all over the body;* and so called from the Latin word "capilla'ris" *(like a hair).*

Q. *Do these* CAPILLARY VEINS *run all over the human body?*

A. Yes. Whenever blood *flows from a wound,* some *vein* must be divided; and as you can scarcely insert a needle into *any* part of the body *without bringing blood,* these little veins must run through every part of the human frame.

Q. *How do* HYDROGEN *gas and* CARBON *get into these very little veins?*

A. The food we eat is *converted into blood,* and blood contains both *hydrogen* and *carbon.*

Q. *How does* COMBUSTION *take place in the capillary veins?*

A. The *carbon of the blood* combines with the *oxygen of the air we breathe,* and forms into *carbonic acid gas.*

Q. *What* BECOMES *of this* CARBONIC ACID GAS *formed in the human blood?*

A. Almost all of it is thrown off by the lungs into the *air,* by the act of respiration.

Q. *What* GAS *is generated in a common* FIRE *by* COMBUSTION ?

A. *Carbonic acid gas,* formed by the union of the *carbon of fuel* with the *oxygen of the air.*

Q. *What* GAS *is generated by a lighted* CANDLE *or* LAMP ?

A. *Carbonic acid gas,* formed by the union of the *carbon* of the *oil* or *tallow* with the *oxygen of the air.*

Q. *What is the cause of* SPONTANEOUS COMBUSTION ?

A. The piled-up goods *ferment* from *heat and damp;* and (during fermentation) *carbonic acid gas is formed,* as in the two former cases.

Q. *Does the* HEAT *of the* HUMAN BODY *arise from the* SAME CAUSE, *as the heat of* FIRE ?

A. Yes, precisely. The *carbon of the blood,* combining with the *oxygen of air inhaled,* produces *carbonic acid gas,* which is attended with combustion.

Q. *If animal heat is produced by* COMBUSTION, *why does not the human body* BURN UP *like a coal or candle ?*

A. It actually does so. Every muscle,

nerve, and organ of the body, actually *wastes away* like a *burning candle;* and (being reduced to air and ashes) is rejected from the system as useless.

Q. *If every bone, muscle, nerve, and organ, is thus consumed by combustion, why is not the* BODY *entirely* CONSUMED?

A. It would be so, unless the parts destroyed *were perpetually renewed:* but as a lamp will not go out, so long as it is *supplied with fresh oil;* neither will the *body* be consumed, so long as it is *supplied with sufficient food.*

Q. *What is the principal* DIFFERENCE *between the combustion of a* FIRE *or* LAMP, *and that of the* HUMAN BODY?

A. In the human body the combustion is effected at a much *lower temperature,* and much more *slowly,* than it is in a lamp or fire.

Q. *How can carbon be made to burn at so* LOW *a temperature in the human body?*

A. Because the carbon in the blood is reduced to very *minute particles;* and these particles are ready to undergo a rapid change, as soon as oxygen is supplied to them.

Q. *When a man is* STARVED, *what parts of the body go first?*

A. First the *fat*, because it is the most combustible; then the *muscles;* last of all, the *brain;* and then the man dies, like a *candle which is burnt out.*

Q. *Why does* WANT *of sufficient* NOURISHMENT *often produce* MADNESS?

A. After the *fat and muscles* of the body have been consumed by animal combustion, the *brain* is next attacked; and (unless the patient dies) *madness must ensue from starvation.*

Q. *Why does a man* SHRINK, *when* STARVED?

A. A starved man shrinks *just as a fire does,* unless it be supplied with sufficient fuel.

Q. *What is the* FUEL *of the* BODY?

A. *Food* is the *fuel* of the *body;* and the *carbon of the food* mixing with the *oxygen of the air,* evolves heat in the same way that a fire or candle does.

Q. *Why is* EVERY *part of the* BODY WARM?

A. Because the capillary veins run through every part of the human body,

and the combustion of blood *takes place in the capillary veins.*

See p. 86.

Q. *Why does* RUNNING *make us* WARM?

A. Because we *inhale air more rapidly,* and cause the blood to pass more rapidly through the *lungs* in contact with it; *running,* therefore, acts upon the capillary veins, as a pair of *bellows* on a common *fire.*

Q. *How does* INHALING AIR RAPIDLY *make the body feel* WARM?

A. As *more oxygen* is introduced into the body, the combustion of the blood is *more rapid,*—the blood itself *more heated,*—and every part of the body is made warmer.

Q. *Why does* HARD WORK *produce* HUNGER?

A. Because it produces *quicker respiration;* by which means, a *larger amount of oxygen is introduced into the lungs,* and the *capillary combustion increased.* Hunger is the *notice* (given by our body) to remind us, *that our food-fuel must be replenished.*

Q. *Why does* SINGING *make us* HUNGRY?

A. Singing *increases respiration;* and as *more oxygen* is introduced into the lungs, *our food-fuel is more rapidly consumed.*

Q. *Why does* READING ALOUD *make us feel* HUNGRY?

A. Reading aloud *increases respiration;* and as *more oxygen* is introduced into the lungs, *our food-fuel is more rapidly consumed.*

Q. *Why do we feel* MORE HUNGRY *in the* DAY-TIME, *than in the* NIGHT?

A. As we *breathe more slowly during sleep*, therefore, less *oxygen* is introduced into the lungs to *consume our food-fuel.*

Q. *Why do we need* WARMER CLOTHING *by* NIGHT *than by* DAY?

A. 1st—Because the *night is generally colder* than the day: and

2ndly—Our *bodies* are *colder* also: because we breathe more *slowly*, and our animal combustion is retarded.

Q. *Why do we* PERSPIRE, *when very hot?*

A. The pores of the body are *like the safety valves of a steam-engine;* when

the heat of the body is very great, some of the combustible matter of the blood is thrown off in *perspiration*, and the heat of the body kept more temperate.

Q. *Why do persons feel* LAZY *and averse to exercise, when they are* HALF-STARVED *or* ILL-FED?

A. *Animal food* contains great nourishment, and produces a desire for *active occupations;* but when the body is not supplied with strong food, this desire for muscular action *ceases,* and the person grows slothful.

Q. *Why have persons, who follow* HARD OUT-OF-DOORS OCCUPATIONS, *more* APPETITE *than those who are engaged in* SEDENTARY *pursuits?*

A. Hard bodily labour in the open air *causes much oxygen* to be conveyed into the *lungs by inspiration;* the combustion of the food is carried on quickly; *animal heat increased;* and need for nutritious food more quickly indicated by *craving hunger.*

Q. *Why have persons, who follow* SEDENTARY PURSUITS *less* APPETITE, *than ploughmen and masons?*

A. 1st—Because the air they inhale

is less pure, being deprived of some of its oxygen: and

2ndly—Their respiration is neither *so quick nor strong;* and, therefore, the combustion of their food is carried on more slowly.

Q. *Why do we like strong* MEAT *and* GREASY *food when the* WEATHER *is very* COLD?

A. Strong meat and grease contain large portions of *carbon* and *hydrogen,* which (when burned in the blood) produce a larger amount of heat, than any other kind of food.

Q. *Why do persons* EAT MORE *food in* COLD *weather, than in hot?*

A. In *cold* weather the body requires more fuel *to keep up the same amount of animal heat;* and as we put more *coals* on a fire (on a cold day), to keep our *room* warm; so we eat more *food* on a cold day, to keep our *body* warm.

Q. *Why does* COLD *produce* HUNGER?

A. 1st—Because the air contains more *oxygen* in cold weather; and, therefore, *fires burn fiercer,* and *animal combustion is more rapid:* and

2ndly—As we are more *active* in cold weather, our increased respiration acts *like a pair of bellows* on the capillary combustion.

Q. *Why does rapid* DIGESTION *produce a craving* APPETITE ?

A. This is a wise providence to *keep our bodies in health;* In order that the *body itself* may not be consumed, it gives notice (by hunger) that the *capillary fires need replenishing.*

Q. *Why do we feel a desire for* ACTIVITY *in cold weather?*

A. 1st—Because activity increases the warmth of the body, *by fanning the combustion of the blood:* and

2ndly—The *strong food* we eat creates a desire for muscular exertion.

Q. *Why are the Esquimaux so passionately fond of* TRAIN OIL *and* WHALE BLUBBER ?

A. Oil and blubber contain large quantities *of carbon and hydrogen,* which are exceedingly combustible; and as these people live in climates of intense cold, the heat of their bodies is increased by the *greasy nature of their food.*

Q. *Why do we feel a* DISLIKE *to strong meat and greasy food in very* HOT *weather?*

A. As strong meat and grease contain so much *carbon and hydrogen,* that they would make us *intensely hot,* we instinctively refuse them in hot weather.

Q. *Why do we like* FRUITS *and* VEGETABLES *most in hot weather?*

A. Because they contain *less hydrogen and carbon* than meat, and therefore produce both *less blood,* and blood of a *less combustible nature.*

Q. *Why is the blood of a less* COMBUSTIBLE *nature, if we live chiefly upon* FRUITS *and* VEGETABLES?

A. Because fruits and vegetables supply the blood with a very large amount of *water;* which is not combustible, like the *carbon and hydrogen* of strong meat.

Q. *How do* FRUITS *and* VEGETABLES COOL *the* BLOOD?

A. 1st—They diminish the amount of *carbon and hydrogen* in the blood, which are the chief causes of animal heat: and

2ndly—They supply the blood with a

large amount of *water*, which *(exhaling through the skin)* leaves the body cool.

Q. *Why do we feel* LAZY *and averse to activity in very* HOT WEATHER?

A. 1st—Because muscular activity increases the heat of the body, by *quickening the respiration*: and

2ndly—The food we eat in hot weather (not being *greasy*) naturally abates our desire for bodily activity.

✝ Q. *Why do the inhabitants of* TROPICAL *countries live chiefly upon* RICE *and* FRUIT?

A. Because rice and fruit (by digestion) *are mainly converted into water*; and *(by cooling the blood)* prevent the tropical heat from feeling so oppressive.

Q. *Why are very* POOR PEOPLE *instinctively* AVERSE *to* CLEANLINESS?

A. 1st—Because *cleanliness increases hunger*; and as very poor people are *ill-fed*, cleanliness would increase their craving: and

2ndly—*Dirt is warm*, (thus pigs who love *warmth*, are fond of *dirt)*; to those, therefore, who are very *ill-clad*, the *warmth of dirt* is agreeable.

Q. *Why are very* POOR PEOPLE *instinctively* AVERSE *to* VENTILATION ?

A. 1st—Because ventilation *increases the oxygen of the air*,—the *combustion of food*,—and the *cravings of appetite*: and

2ndly—Ventilation *cools the air of our rooms:* to poor people, therefore, who are ill-clad, the *warmth* of an ill-ventilated apartment is agreeable.

Q. *Why does* FLANNEL, *&c. make us* WARM ?

A. Flannel and warm clothing do not *make* us warm, but merely *prevent our body from becoming cold.*

Q. *How does* FLANNEL, *&c. prevent our body from becoming cold ?*

A. Flannel (being a bad conductor) will neither *carry off the heat of the body* into the *cold air*, nor suffer the cold of the air *to come into contact with our warm bodies;* and thus it is, that flannel clothing keeps us warm.

Q. *Why are* FROGS *and* FISHES COLD-BLOODED *animals ?*

A. Because they consume but very *little air;* and without a plentiful supply of air, combustion is so slow, that very little animal heat is evolved.

Q. *Why is a* DEAD BODY COLD?

A. Because air is no longer conveyed to the lungs, after respiration has ceased; and, therefore, animal heat *is no longer evolved by combustion.*

CHAPTER VII.

MECHANICAL ACTION.

1.—PERCUSSION.

Q. *How is heat produced by* MECHANICAL ACTION?

A. 1.—By Percussion. 2.—By Friction. And 3.—By Condensation.

Q. *What is meant by* PERCUSSION?

A. *The act of striking;* as when a blacksmith strikes a piece of iron on his anvil with his hammer.

Q. *Why does* STRIKING IRON *make it* RED HOT?

A. *Striking* the iron *condenses the particles* of the metal; and makes the latent heat become *sensible.*

Q. *Does* COLD *iron contain* HEAT?

A. Yes; *every thing* contains heat; but when a thing *feels cold,* its heat is LATENT.

Q. *What is meant by* LATENT HEAT?

A. Heat *not perceptible to our feeling.* When anything contains *heat* without *feeling* the hotter for it, that heat is called "*latent.*"

See p. 33.

Q. *Does* COLD *iron contain latent* HEAT?

A. Yes; and when a blacksmith *compresses the particles* of the iron by his hammer, he brings *out* latent heat, and this makes the iron red-hot.

Q. *How used blacksmiths to* LIGHT THEIR MATCHES, *before the general use of lucifers?*

A. They used to place a soft iron nail upon their anvil; strike it two or three times with a hammer; and the point became *sufficiently hot to light a brimstone match.*

Q. *How can a* NAIL (*beaten by a hammer*) IGNITE *a brimstone* MATCH?

A. When the particles of the nail are *compressed* by the hammer, they cannot contain so much heat in a *latent state* as they did *before;* so some of it becomes *sensible,* and increases the temperature of the iron.

Q. *Why does* STRIKING *a* FLINT *against a piece of* STEEL *produce a* SPARK?

A. The blow compresses those parts of the flint and steel which strike *together,* and some of their latent heat (being disturbed) is developed in a spark.

Q. *How does this development of* HEAT *produce a* SPARK, *and set* TINDER *on fire?*

A. A very small fragment (either of the steel or flint) *is knocked off red-hot,* and sets fire to the tinder on which it falls.

Q. *Why is it needful to keep* BLOWING *the* TINDER *with the breath?*

A. In order that the increased supply of air may furnish the tinder with more *oxygen* to assist combustion.

Q. *Where does the* OXYGEN *of the air* COME FROM, *which is blown to the lighted tinder?*

A. From the air itself, which is com-

posed of two gases *(nitrogen and oxygen)* mixed together.

Every 5 gallons of common air contain 4 gallons of nitrogen, and 1 of oxygen.

Q. *What is the* USE *of* OXYGEN GAS *to lighted tinder?*

A. Oxygen gas *supports combustion:* *blowing* lighted tinder carries *oxygen* to it and *quickens* it, in the same way as a pair of bellows quickens a dull fire.

Q. *Why do* HORSES *sometimes* STRIKE FIRE *with their* FEET?

A. When iron horse-shoes strike against the flint-stones of the road, *very small fragments* (either of the shoe or stones) are *knocked off red-hot,* and look like sparks.

Q. *What makes these fragments* RED-HOT?

A. The percussion *condenses* the part struck; and some of its *latent heat* (rendered *sensible*) produces this red heat.

CHAPTER VIII.



2.—FRICTION.

3.—CONDENSATION.

Q. *What is meant by* FRICTION ?

A. The act of *rubbing two things together;* as the Indians rub two pieces of *wood* together to produce fire.

Q. *How do the Indians produce* FIRE, *by merely* RUBBING TWO PIECES *of dry* WOOD TOGETHER ?

A. They take a piece of dry wood (sharpened to a point), which they rub quickly up and down a *flat piece,* till a *groove* is made; and the *dust* (collected in this groove) *catches fire.*

Q. *Why does the dust of the* WOOD CATCH FIRE *by* RUBBING ?

A. Because *latent heat* is developed from the wood *by friction.*

The best woods for this purpose are *box-wood* against *mulberry,* or *laurel* against *poplar* or *ivy.*

Q. *Do not* CARRIAGE WHEELS *sometimes* CATCH FIRE?

A. Yes; if the wheels be *dry,*—or *fit too tightly,*—or *revolve very rapidly,*—they often catch fire.

Q. *Why do wheels catch fire in such cases?*

A. Because the *friction* of the wheels against *the axle-tree* disturbs their *latent heat,* and produces ignition.

Q. *What is the use of* GREASING CART WHEELS?

A. The grease *lessens the friction;* and (by diminishing the *friction)* the latent heat is less disturbed.

Q. *Why does* RUBBING *our* HANDS *and* FACES *make them feel* WARM?

A. 1st—Because friction *excites the latent heat* of our hands and faces, and makes it sensible to our feeling: and

2ndly—As the blood is made to *circulate more quickly*—the quantum of heat (left in its passage) is increased also.

Q. *When a man has been almost* DROWNED, *why is suspended animation* RESTORED *by* RUBBING?

A. 1st—Because friction *excites the latent heat* of the half-inanimate body: and

2ndly—It makes the *blood circulate more quickly,* which increases the animal heat.

Q. *Why do two pieces of* ICE *(rubbed together)* MELT?

A. Ice contains 140 *degrees of latent heat,* and (when two pieces are *rubbed together)* some of this latent heat is made *sensible,* and melts the ice.

Q. *Are not* FORESTS *sometimes* SET *on* FIRE *by friction?*

A. Yes; when two branches or trunks of trees (blown about by the wind) *rub violently against each other,* their *latent heat is developed,* and sets fire to the forest.

3.—CONDENSATION *or* COMPRESSION.

Q. *What is meant by* COMPRESSION?

A. The act of *bringing parts nearer together;* as a sponge is *compressed* by being *squeezed in the hand.*

Q. *Cannot* HEAT *be evolved from common air merely by* COMPRESSION?

A. Yes; if a piece of *German tinder* be placed at the *bottom of a glass tube,* and the air in the tube *compressed by a piston,** the tinder will catch fire.

Q. *Why will the tinder catch fire?*

A. Because the *air is compressed;* and its *latent heat being squeezed out,* sets fire to the tinder at the bottom of the tube.

Q. *When an* AIR-GUN *is discharged in the dark, why is it accompanied with a slight* FLASH?

A. Because the *air* is very rapidly *condensed,* and its latent heat developed in a *flash of light.*

N.B. If a glass lens be fixed in the copper ball, where the *air* of the gun is *condensed,* a flash of light may be distinctly discerned at the stroke of the piston.

Q. *Why is the* TOP *of a* MOUNTAIN COLDER *than the* VALLEY *beneath, although it be two or three miles nearer the sun?*

A. 1st.—Because the air on a mountain is *less compressed,* than that in a valley: and

2ndly—It is less heated by reflection.

* In a common syringe or squirt, the *handle* part (which *contains the sucker,* and is forced up and down), is called "The Piston."

Q. *Why is air on a mountain* COLDER, "*because it is less compressed.*"

A. As the air on a mountain is not compressed by so large a volume of air as that below, less of its latent heat is disturbed and rendered sensible.

Q. *Why is a mountain-top* COLD, "*because the air is not heated by* REFLECTION?"

A. Air is *not* heated by the *sun,* but by *reflection from the surface of the earth;* and as there is *no earth* round a *mountain-top* to reflect heat, therefore, the air there is intensely cold.

CHAPTER IX.

EFFECTS OF HEAT.

1.—EXPANSION.

Q. *What are the principal* EFFECTS *of* HEAT?

A. 1.—Expansion. 2.—Liquefaction. 3.—Vaporization. 4.—Evaporation; and 5.—Ignition.

Q. *Does* HEAT EXPAND AIR?

A. Yes; if a bladder (partially filled with air) be tied up at the neck, and *laid before the fire*, the air will expand till the bladder *bursts*.

Q. *Why will the* AIR SWELL, *if the bladder be laid before the fire?*

A. Because the heat of the fire drives the particles of air *apart from each other*, and causes them to occupy more room than they did before.

Q. *Why do unslit* CHESTNUTS CRACK *with a loud noise, when* ROASTED?

A. Chestnuts contain a great deal of air, which is expanded by the heat of the fire; and (not being able to make its escape through the thick rind) *bursts* violently through, *slitting the rind*, and making a great noise.

Q. *What occasions the loud* CRACK *or report which we hear?*

A. 1st—The *sudden bursting of the rind* makes a report, in the same way as a piece of *wood* or *glass* would do, if *snapped in two:* and

2ndly—The *escape of hot air* from

the chestnut makes a report also, in the same way as *gunpowder*, when it escapes from a *gun*.

Q. *Why does the sudden* BURSTING *of the rind, or* SNAPPING *of a piece of wood, make a* REPORT?

A. As the attraction of the parts is suddenly overcome, *a violent jerk* is given to the air; this jerk produces *rapid undulations* in the air, which (striking upon the ear) give the brain the sensation of *sound*.

Q. *Why does the* ESCAPE OF AIR *from the chestnut, or the* EXPLOSION *of* GUNPOWDER, *produce a* REPORT?

A. Because the very sudden expansion of the imprisoned gases, or air, produces a partial vacuum; the *report* is caused by the *air rushing* to fill up the vacuum.

Q. *If a* CHESTNUT *be* SLIT, *it will* NOT CRACK; *why is this?*

A. Because the *heated air* of the chestnut can *freely escape* through the *slit in the rind*.

Q. *Why does an* APPLE *spit and* SPURT *about, when roasted?*

A. An apple contains a vast quantity of *air*, which (being expanded by the heat of the fire) *bursts through the peel,* carrying the juice of the apple along with it.

Q. *Does an* APPLE *contain* MORE AIR, *in proportion, than a* CHESTNUT?

A. Yes, much more. There is as much condensed air in a common apple, as would fill a space 48 *times as large as the apple itself.*

Q. *Where is all this quantity of* AIR *stowed in the* APPLE?

A. The *inside* of an apple consists *of little cells* (like a *honey-comb),* each of which contains a portion of the air.

Q. *When an* APPLE *is* ROASTED, *why is one part made* SOFT, *while all the rest remains hard?*

A. When an apple is roasted, the air in the *cells next the fire* is expanded, and flies out; the *cells are broken,* and their juices *mixed together;* so the apple *collapses* (from loss of air and juice), and feels *soft* in those parts.

Q. *What is meant by the "apple* COLLAPSING?"

A. The *plumpness* gives way, and the apple becomes *flabby* and *shrivelled.*

Q. *Why do* SPARKS *of fire start (with a crackling noise) from pieces of* WOOD *laid upon a* FIRE ?

A. Because the *air* (expanded by the heat) *forces its way through the pores of the wood;* and carries along with it the *covering of the pore,* which resisted its passage.

Q. *What is meant by the* "PORES *of the* WOOD?"

A. Very small *holes in the wood,* through which the *sap* circulates.

Q. *What are the* SPARKS OF FIRE, *which burst from the* WOOD?

A. Very small pieces of wood made *red-hot,* and separated from the log by the *force of the air,* bursting from its confinement.

Q. *Why does* DEAL *make more snapping, than any* OTHER WOOD ?

A. Because the pores of deal are *very large,* and contain much *more air* than wood of a *closer grain.*

Q. *Why does* GREEN WOOD *make* LESS SNAPPING *than* DRY ?

A. Because the pores are filled with *sap;* and, therefore, contain *very little air.*

Q. *Why does* DRY WOOD *make* MORE SNAPPING *than green?*

A. Because the sap is *dried up,* and the pores are filled with *air* instead.

Q. *Why does* DRY *wood* BURN *more easily than* GREEN *or wet wood?*

A. Because the pores of dry wood are *filled with air,* which supports combustion; but the pores of green or wet wood are filled with *moisture,* which extinguishes flame.

Q. *Why does* MOISTURE EXTINGUISH FLAME?

1st.—Because it prevents the *hydrogen* of the fuel from mixing with the *oxygen* of the air, to form *carbonic acid gas:* and

2ndly—Heat is perpetually carried off, by the formation of the sap or moisture *into steam.*

Carbonic acid gas is a compound of carbon and oxygen. The *carbon* comes from the *fuel,* and the *oxygen* from the *air.* See p. 35.

Q. *Why do* STONES SNAP *and fly about, when heated in the* FIRE?

A. Because when the air therein is expanded by the heat of the fire, it *meets with great resistance* from the close texture

of the stone; in consequence of which, it *bursts forth with great violence*, tearing the stone to atoms, and forcing the fragments into the room.

Q. *When bottled* ALE *or* PORTER *is set before a* FIRE, *why is the* CORK FORCED OUT *sometimes?*

A. Because the *carbonic acid* of the liquor *expands* by the heat, and drives out the cork.

Q. *Why does* ALE *or* PORTER FROTH *more, after it has been set before the fire?*

A. Because the heat of the fire sets free the *carbonic acid* of the liquor; which is entangled as it rises through the liquor, and produces bubbles or froth.

Q. *When a boy makes a* BALLOON, *and sets fire to the cotton or sponge (which has been steeped in spirits of wine) why is the balloon* INFLATED *or blown out?*

A. Because the *air* inside of it is *expanded by the flame*, till the whole balloon is inflated without a crumple.

Q *Why does the* BALLOON RISE, *after it has been inflated by the expanded air?*

A. Because the same quantity of air

is expanded *to three or four times its original volume;* and made so much *lighter than common air,* that even when all the paper, wire, and cotton are added, it is still lighter bulk for bulk.

Q. *What is meant by being lighter "bulk for bulk?"*

A. If the balloon be 3 cubic feet in size, it is *lighter* (when inflated) than 3 cubic feet of *common air,* and therefore *rises through it,* as a cork (at the bottom of a tub of water) would rise to the surface.

Q. *Why does* SMOKE RUSH UP *a* CHIMNEY?

A. Because the heat of the fire *expands the air in the chimney;* which (being thus made *lighter* than the air around) *rises up the chimney,* and carries the smoke in its current.

Q. *Why will a* LONG *chimney* SMOKE, *unless the* FIRE *be pretty* FIERCE?

A. Because the heat of the fire will not be sufficient to *rarefy all the air in the chimney.*

Q. WHY *will the chimney smoke, if the fire be not* FIERCE *enough to heat* ALL *the air in the* CHIMNEY FLUE?

A. Because the *cold air* (condensed in the upper part of the flue) *will sink from its own weight;* and sweep the ascending smoke *back with it* into the room.

Q. *What is the use of a* COWL *upon a chimney-pot?*

A. The cowl acts as a *screen against the wind,* to prevent it from blowing into the chimney.

Q. *What* HARM *would the* WIND *do, if it were to* BLOW *into a* CHIMNEY?

A. 1st—It would prevent the smoke from getting out: and

2ndly—The *cold air* (introduced into the chimney by the wind) *would fall down the flue,* and drive the smoke with it *into the room.*

Q. *Why does a* SMOKE-JACK *turn round in a chimney?*

A. Because the current of hot air up the chimney (striking against the *oblique vanes of the smoke-jack)* drives them round and round; in the same way as *wind* drives round the sails of a *wind-mill.*

Q. *Why are some things* SOLID, *others* LIQUID, *and others* GASEOUS?

A. Because the particles which compose some things are nearer together than they are in others.—Those in which the particles are *closest* are *solid;* those in which they are *furthest apart* are *gaseous;* and the rest *liquid.*

Q. *Why does heat change a* SOLID *(like ice) first into a* LIQUID, *and then into a* GAS?

A. Because heat drives the component particles further *asunder;* hence a certain quantity of heat changes solid ice into a *liquid,* and a further addition of heat changes the liquid into *steam.*

Q. *Why does* WATER SIMMER *before it boils?*

A. Because the particles of water *near the bottom of the kettle* (being formed into *steam* sooner than the rest) *shoot upwards;* but are *condensed* again (as they rise) *by the colder water,* and produce what is called "simmering."

Q. *What is meant by* SIMMERING?

A. A gentle tremor or *undulation* on the surface of the water. When water *simmers,* the bubbles *collapse beneath the*

surface, and the steam is condensed to *water again:* but when water *boils*, the bubbles *rise to the surface*, and *steam is thrown off.*

Collapse, i. e. burst.

Q. *Why does a* KETTLE SING, *when the water simmers?*

A. Because the *air* (entangled in the water) escapes by *fits and starts* through the *spout of the kettle;* which makes a noise like a wind instrument.

Q. *Why does* NOT *a kettle* SING, *when the water* BOILS?

A. Because (as *all* the water is *boiling hot)* the steam escapes in a *continuous stream*, and not by *fits* and *starts.*

Q. *When does a kettle sing* MOST?

A. When it is set on the *hob* to boil.

Q. *Why does a kettle* SING MORE *when it is set on the* SIDE *of a fire, than when it is set in the* MIDST *of the fire?*

A. Because (when the kettle is set on the *hob* to boil) the heat is applied very *partially*, and *one side made hotter than the other;* in consequence of which, the steam is more *entangled.*

Q. *Why does a* KETTLE *sing, when the boiling water begins to* COOL *again?*

A. Because the *upper* surface cools *first;* and the steam which rises from the lower part of the kettle is *again entangled,* and escapes fitfully.

Q. *Why does* BOILING WATER SWELL?

A. Because water (like air) *expands by heat:* i. e. The heat of the fire drives the particles of water *further apart from each other:* and (as they are not *packed so closely together)* they take up *more room;* (in other words) the water *swells.*

Q. *What is meant when it is said, "that* HEAT *drives the* PARTICLES *of water further* APART *from each other."*

A. Water is composed of little globules, like very small grains of sand; the heat *drives* these particles away from each other; and (as they then require more *room)* the water *swells.*

Q. *Why does* BOILING WATER BUBBLE?

A. Because the *air and vapour* (rising through the water) are *entangled,* and force up bubbles in their effort to escape.

Q. *Why does a* KETTLE *sometimes* BOIL OVER?

A. Liquids *expand very much by heat;* if, therefore, a kettle be *filled with cold water,* some of it must *run over,* as soon as it is *expanded by heat.*

Q. *But I have seen a* KETTLE BOIL OVER, *although it has not been filled* FULL *of* WATER; *how do you account for* THAT?

A. If a fire be *very fierce,* the air and vapour are expelled so *rapidly,* that the *bubbles are very numerous;* and (towering one above another) reach the *top of the kettle,* and *fall over.*

Q. *Why is a pot (which was full to* OVERFLOWING, *while the water was boiling* HOT) NOT FULL, *after it has been taken off the fire for a short time?*

A. Because (while the water is *boiling)* it is *expanded* by heat, and fills the pot even to overflowing; but when it becomes cool it *contracts* again, and occupies a much less space.

Q. *Why does the water of a* KETTLE *run out of the* SPOUT, *when it* BOILS?

A. Because the lid fits so tightly, that the steam cannot lift it up, and

escape; being confined, therefore, in the kettle, it *presses on the water* with great power, and forces it out of the spout.

Q. *What causes the* RATTLING NOISE, *so often made by the* LID *of a saucepan or boiler?*

A. The steam (seeking to escape) *forces up the lid* of the boiler, and the *weight* of the lid carries it *back again:* this being done *frequently*, produces a rattling noise.

Q. *If the steam* COULD NOT LIFT UP THE LID *of the boiler, how would it escape?*

A. If the lid fitted so tightly, that the steam could not raise it up, the boiler would *burst into fragments*, and the consequences might be fatal.

Q. *When steam pours out from the spout of a kettle, the* STREAM *begins apparently* HALF AN INCH *off the* SPOUT; *why does it not begin* CLOSE *to the spout?*

A. Steam is really *invisible;* and the half-inch (between the spout and the "*stream of mist*") is the *real steam*, before it has been condensed by air.

Q. *Why is not* ALL *the steam* INVISIBLE, *as well as that half-inch?*

A. Because when the steam *comes in contact with the colder air*, the invisible particles (being *condensed)* roll one into another, and look like a thick mist.

Q. *What* BECOMES *of the* STEAM? *for it soon vanishes.*

A. After it has been condensed into mist it is *dissolved by the air*, and dispersed abroad as *invisible vapour.*

Q. *And what* BECOMES *of the* INVISIBLE VAPOUR?

A. Being *lighter* than air, it *ascends* to the upper regions of the atmosphere, where (being again *condensed)* it contributes to form *clouds.*

Q. *Why does a* METAL SPOON *(left in a saucepan)* RETARD *the process of* BOILING?

A. Because the metal spoon (being an excellent *conductor*) *carries off the heat from the water;* and (as heat is carried off by the spoon) the water takes a longer time to boil.

Q. *Why will a* POT *(filled with water)* NEVER BOIL, *when immersed in* ANOTHER *vessel full of water also?*

A. Because water can never be heated

above the boiling point: all the heat absorbed by water after it *boils,* is employed in generating *steam.*

Q. *How does the conversion of water into steam, prevent the* INNER POT *from* BOILING?

A. Directly the water in the larger pot is *boiling hot* (or 212°), *steam is formed,* and *carries off some of its heat;* therefore, 212 degs. of heat can never *pass through it,* to raise the *inner* vessel to *boiling heat.*

Q. *Why do* SUGAR, SALT, *&c.* RETARD *the process of* BOILING?

A. Because they increase the *density* of water; and whatever increases the *density* of a fluid, retards its boiling.

Q. *If you want water to boil, without* COMING IN CONTACT *with the* SAUCEPAN, *what plan must you adopt?*

A. *Immerse the pot* (containing the water to be boiled) in a saucepan containing *strong brine,* or sugar.

Q. *Why would the* INNER *vessel boil, if the* OUTER *vessel contained strong* BRINE?

A. Though *water* boils at 212 *degs.* of heat, yet *brine* will not boil till raised

to 218 or 220 *degs.* Therefore, 212 *degs.* of heat may easily pass through brine, *to raise the vessel immersed in it to boiling heat,* before any of it is *carried off by steam.*

Q. *Why will brine impart to another vessel* MORE *than* 212°, *and water* NOT SO MUCH?

A. Because both liquids will *impart heat* till they *boil;* and then they can *impart heat no longer.*

Q. *Why can they impart no* EXTRA *heat, after they boil?*

A. Because all *extra* heat is spent *in making steam.* Hence water will not boil a vessel of *water* immersed in it, because it cannot impart to it 212 *degs.* of heat, but *brine* will; because it can impart *more than* 212 *degs. of heat,* before it is *itself* converted into steam.

Ether boils at	104 *degs.*	Syrup boils at	221 *degs*
Alcohol - -	173½ „	Oil of turpentine	304 „
Water - -	212 „	Sulphuric acid -	472 „
Water, with one-fifth salt -	219 ..	Linseed oil -	640 „
		&c. &c.	

Any liquid which boils at a *lower* degree can be made to boil, if immersed in a liquid which boils at a *higher* degree. Thus a *cup of ether* can be made to boil in a saucepan of *water.* A *cup of water* in a saucepan of *brine or syrup.* But a *cup of water* will *not* boil, if immersed in *ether;* nor a *cup of syrup* in *water.*

Q. *Why are* CLOUDS HIGHER *on a* FINE DAY?

A. Because they are *lighter,* and *more buoyant.*

Q. *Why are* CLOUDS LIGHTER *on a* FINE DAY?

A. 1st—Because the vapour of the clouds is less *condensed;* and

2ndly—The *air itself* (on a fine day) retains much of its vapour in an *invisible* form.

Q. *Why is a* CUP *put* INVERTED *into a* FRUIT-PIE?

A. Its principal use is to *hold the crust up,* and *prevent it from sinking* when the cooked fruit gives way under it.

Q. *Does not the cup* PREVENT *the* FRUIT *of the pie from* BOILING OVER?

A. No, by no means; it would rather tend to *make it boil over,* than otherwise.

Q. WHY *would the cup tend to* MAKE *the* FRUIT BOIL OVER?

A. Because (when the pie is put into the oven) the *air* in the cup will *begin to expand,* and drive every particle of juice from under it; in consequence of which, the pie-dish will have a cup-full *less room* to hold its fruit in, than if the cup were *taken out.* M 2

Q. *If the juice is driven* OUT *of the cup; why is the* CUP *always* FULL *of* JUICE, *when the pie is cut up?*

A. Because immediately the pie is *drawn*, the air in the cup begins to *condense again*, and occupy a *smaller space;* and as the cup is no longer full of *air*, *juice* rushes in to occupy the void.

Q. *Why does* JUICE *rush into the cup, because the cup is* NOT FULL *of* AIR?

A. Because (when the external air *presses upon the surface of the juice*) it rushes *unobstructed* into the cup; as mercury rises through the tube of a barometer through similar pressure.

N. B. Since the juice of the pie runs into the cup, as soon as it is taken out of the oven; the cup prevents the juice from being *spilt over the crust*, when the pie is carried about from place to place; although it does not prevent the fruit from boiling over.

CHAPTER X.

EXPANSION FROM HEAT.

(Continued.)

Q. *Does heat expand every thing* ELSE, *besides air and water?*

A. Yes; *every* thing (that man is acquainted with) is expanded by heat.

Q. *Why does a* COOPER *heat his* HOOPS RED-HOT, *when he puts them on a tub?*

A. 1st—As *iron expands by heat,* the hoops will be *larger* when they are red-hot; in consequence of which, they will fit on the tub *more easily:* and

2ndly—As *iron contracts by cold,* the hoops will *shrink* as they cool down, and *girt the tub with a tighter grasp.*

Q. *Why does a* WHEELWRIGHT *make his hoops* RED-HOT, *which he fixes on the* NAVE *of a* WHEEL?

A. 1st—That they may *fit on more easily:* and

2ndly—That they may *girt the nave more tightly.*

Q. *Why will the wheelwright's* HOOP FIT *the nave* MORE EASILY, *because made* RED-HOT?

A. As *iron expands by heat,* the hoops will be *larger* when they are hot; and (being larger) will go on the nave more *easily.*

Q. *Why will the* HOOPS, *which have been* PUT ON HOT, GIRT *the nave more* FIRMLY?

A. As *iron contracts by cold,* the hoops will *shrink* when they cool down; and *girt the nave with a tighter grasp.*

Q. *Why does a* STOVE *make a* CRACKING NOISE, *when a fire is very hot?*

A. Because (when the iron stove *expands* from heat) the parts *rub* against each other, and drive the *bricks* further off; and this disturbance produces a *cracking* noise.

Q. *Why does a* STOVE *make a similar* CRACKING NOISE, *when a large* FIRE *is* TAKEN DOWN?

A. Because (when the fire is removed) as the iron stove *contracts again,* the parts again *rub against each other,* and the *bricks are again disturbed;* in consequence of which, the cracking noise is repeated.

Q. *Why does the* PLASTER *round a* STOVE CRACK *and fall away?*

A. Because (when the fire is lighted) as the *iron-work* expands more than the brick-work and plaster, it *pushes them away;* but (when the fire is put out) the metal *shrinks* again, and leaves the "setting" behind.

Q. *Why does the* PLASTER FALL AWAY?

A. As a *chink* is left (between the "setting" and the stove), the plaster will frequently fall away *from its own weight.*

Q. *What* OTHER *cause contributes to* BRING *the* PLASTER DOWN?

A. As the *heat of the fire* varies, the *size of the iron stove* varies also; and this swelling and contracting keep up such a constant *disturbance about the plaster,* that it *cracks and falls off,* leaving the fire-place very unsightly.

Q. *Why does the* MERCURY *of a* THERMOMETER RISE *in hot weather?*

A. Because heat *expands the metal,* which (being *increased in bulk)* occupies a *larger space;* and, consequently, rises higher in the tube.

Q. *Why is a* GLASS BROKEN, *when* HOT WATER *is poured into it?*

A. Because the *inside* of the glass is expanded by the hot water, and *not the outside;* so the glass *snaps,* in consequence of this unequal expansion.

Q. *Why is not the* OUTSIDE *of the* GLASS *expanded by the hot water, as well as the* INSIDE?

A. Because glass is a *non-conductor of heat,* and *breaks* before the heat of the *inner* surface is conducted to the *outside.*

Q. *Why does a* GLASS *snap, because the* INNER *surface is* HOTTER *than the* OUTER?

A. Because the *inner* surface being expanded and not the *outer,* an *opposing force* is created, which breaks the glass.

Q. *Why is a* CHINA CUP *broken, if* HOT WATER *be poured over it, or into it?*

A. Because it is a *non-conductor;* and (as the *inner surface expands* from the heat, and not the *outer*), an *opposing force* is created, which breaks the cup.

Q. *If a* GLASS BEAKER *be set on a warm* HOB, *why does the* BOTTOM COME OFF?

A. Because glass is a *non-conductor;* and (as the *bottom* of the glass expands from the warmth of the hot stove, before the *sides* are heated) the two parts *separate* from each other.

CHAPTER XI.



2.—LIQUEFACTION.

3.—VAPORIZATION.

Q. *What is meant by* LIQUEFACTION?

A. The *state of being melted*; as ice is melted by the heat of the sun.

Q. *Why is* ICE MELTED *by the* HEAT *of the* SUN?

A. Because when the *heat of the sun* enters the solid ice, it *forces its particles asunder*, till their attraction of cohesion is sufficiently overcome, to *convert the solid ice into a liquid.*

See p. 115.

Q. *Why are* METALS MELTED *by the heat of* FIRE?

A. Because when the heat of the fire enters the solid metal, it *forces its particles asunder;* till their attraction of cohesion is sufficiently overcome, to *convert the solid metal into a liquid.*

Q. *Why is* WATER *converted to* STEAM *by the heat of* FIRE?

A. Because when the heat of the fire enters the water, it separates its *globules* into very *minute bubbles;* which (being lighter than air) fly off from the surface *in the form of steam.*

Q. *Why does not* WOOD MELT, *like metal?*

A. Because the heat of the fire *decomposes* the wood into *gas, smoke, and ashes;* and the different parts *separate from each other.*

Q. *What is meant by* VAPORIZATION?

A. The *conversion of a solid or liquid into vapour;* as snow or water is converted into vapour by the heat of the sun.

Q. *What are* CLOUDS?

A. Moisture *evaporated from the earth,* and again partially *condensed* in the upper regions of the air.

Q. *What is the difference between a* FOG *and a* CLOUD?

A. Clouds and fogs differ only in one respect. *Clouds are elevated above our heads:* but *fogs come in contact with the surface of the earth.*

Q. *Why do* CLOUDS FLOAT *so readily in the air?*

A. Because clouds are composed of *very minute globules* (called ves'cicles); which (being lighter than air) float, as *soap bubbles* would do if inflated with hydrogen gas.

Q. *Why does* VAPOUR *sometimes form into* CLOUDS, *and sometimes rest upon the earth as* MIST *or* FOG?

A. When the *surface of the earth* is *warmer than the air,* the vapour of the earth (being condensed by the chill *air)* becomes *mist or fog.* But when the *air* is *warmer than the earth,* the vapour *rises through the air,* and becomes cloud.

Q. *Are* ALL *clouds* ALIKE?

A. No. They vary greatly in *density, height, and colour.*

Q. *What is the chief* CAUSE *of fog and* CLOUDS?

A. The changes of the wind.

Many *local* circumstances also favour the formation of clouds.

Q. *How can the* CHANGES *of the* WIND *affect the* CLOUDS?

A. If a *cold current of wind* blows

suddenly over any region, it *condenses* the invisible vapour of the air into *cloud or rain:* but if a *warm current of wind* blows over any region, it *disperses* the clouds, by *absorbing their vapour.*

Q. *What* COUNTRIES *are the* MOST CLOUDY?

A. Those where the winds are *most variable,* as Britain.

Q. *What* COUNTRIES *are the* LEAST *cloudy?*

A. Those where the winds are *least variable,* as Egypt.

Q. *What* DISTANCE *are the* CLOUDS *from the* EARTH?

A. Some *thin light clouds* are elevated above the highest mountain-top; some *heavy* ones touch the steeples, trees, and even the earth: but the *average* height is between *one and two miles.*

N.B. Streaky curling clouds, *like hair,* are often 5 or 6 miles high.

Q. WHAT CLOUDS *are the* LOWEST?

A. Those which are *most highly electrified:* lightning clouds are rarely more than about 700 yards above the ground; and often actually *touch the earth with one of their edges.*

Q. *What is the* SIZE *of the* CLOUDS?

A. Some clouds are 20 *square miles in surface,* and above *a mile in thickness;* while others are only a *few yards or inches.*

Q. *How can persons ascertain the* THICKNESS *of a cloud?*

A. As the *tops of high mountains* are generally above the clouds, travellers may pass *quite through the clouds* into a clear blue firmament; when the clouds will be seen *beneath their feet.*

Q. *Why are the* CLOUDS *so* VARIABLE *in* SHAPE?

A. The *shape* of clouds depends upon three things: 1st—The cause and manner of their *formation:*

2ndly—Their *electrical* condition: and

3rdly—Their relations to *currents of wind.*

Q. *How can* ELECTRICITY *affect the* SHAPE *of* CLOUDS?

A. If one cloud be *full of electricity* and another *not,* they will be *attracted to each other,* and either coalesce,—diminish in size,—or vanish altogether.

Q. WHAT CLOUDS *assume the most* FANTASTIC *shapes?*

A. Those that are the most *highly electrified.*

Q. *What effect have* WINDS *on the* SHAPE *of* CLOUDS?

A. They sometimes *absorb them entirely:* sometimes *increase their volume and density;* and sometimes *change the position of their parts.*

Q. *How can* WINDS ABSORB CLOUDS *altogether?*

A. *Warm dry winds* will convert the substance of clouds into *invisible vapour,* and carry it in their own current.

Q. *How can* WINDS INCREASE *the bulk and density of* CLOUDS?

A. *Cold* currents of wind will condense the *invisible vapour of the air,* and *add it to the clouds* with which they come in contact.

Q. *How can* WINDS CHANGE *the* SHAPE *of* CLOUDS, *by altering the position of their parts?*

A. Clouds are so voluble and light, that every breath of wind changes the position of their ves'icles or bubbles.

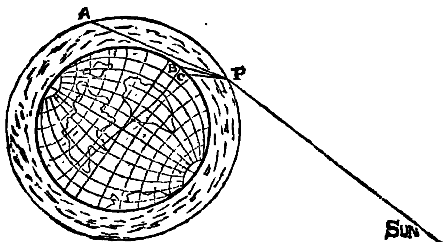
Q. *What are the general* COLOURS *of the* CLOUDS?

A. White and grey, when the sun is *above the horizon:* but red, orange, and yellow, at *sun-rise* and *sun-set.*

The *blue sky* cannot be considered as *cloud* at all.

Q. *Why are the* LAST CLOUDS *of* EVENING *generally of a* RED *tinge?*

A. Because *red* rays (being the *least refrangible of all) are the last to disappear.*



Here it will be seen that the red ray P A, being refracted to the horizon at A, will be visible to us; but the YELLOW and BLUE rays (P B and P C) will be hidden by the curve of the earth.

Q. *What is meant by being* "LESS REFRANGIBLE"?

A. Being *less able to be bent.* Blue and yellow rays being very easily bent

(by the resistance of the air) are thrown *below the horizon;* but red rays not being so much *bent back*, fall upon the evening clouds, and tinge them.

As at A in the figure on p. 135.

Q. *Why are* MORNING CLOUDS *generally of a* RED *tinge?*

A. Because red rays are the *least refrangible* of all, and not being *bent* (like blue and yellow) *below the horizon*, give a tinge to the morning clouds.

See the figure and its explanation on p. 135.

Q. *Why is not the colour of clouds always* ALIKE?

A. Because their *size, density,* and *situation* in regard to the sun, vary perpetually; so that sometimes *one* colour is reflected, and sometimes *another*.

Q. *What regulates the* MOTION *of the* CLOUDS?

A. The *motion of the clouds* is generally directed by the *winds;* but sometimes *electricity* will influence their motion also.

Q. *How do you know that* CLOUDS *move by* OTHER *influences, besides* WIND?

A. Because (in calm weather) we often see *small clouds meeting each other* from opposite directions.

Q. *How do you know that* ELECTRICITY *affects the motion of the clouds?*

A. Because clouds often meet from *opposite directions;* and (after they have discharged their opposite electricities into each other) *vanish altogether.*

Q. *Into how many* CLASSES *are the different sorts of* CLOUDS *generally divided?*

A. Into three classes:—viz. Simple, Intermediate, and Compound.

Q. *How are* SIMPLE CLOUDS *sub-divided?*

A. Into 1.—Cirrus; 2.—Cum'ulus; and 3.—Stra'tus clouds.

Q. *What sort of* CLOUDS *are called* CIRRUS?

A. Clouds like *fibres, loose hair,* or *thin streaks,* are called "cirrus clouds."

Q. *Why are these clouds called* CIRRUS?

A. From the Latin word *cirrus* ("a lock of hair, or curl"): Cirrus clouds are the *most elevated of all.*

Q. *What do* CIRRUS *clouds* PORTEND?

A. When the streamers point *upwards,* the clouds are *falling,* and *rain is at hand:* but when the streamers point *downwards,* expect easterly winds or drought.

Q. *What sort of* CLOUDS *are called* CUM'ULUS?

A. Cum'ulus clouds are lumps, like great *sugar-loaves,—volumes of smoke,*— or *mountains towering over mountains.*

Q. *Why are these monster masses called* CUM'ULUS CLOUDS?

A. From the Latin word *cum'ulus* ("a mass or pile").

Q. *What do* CUM'ULUS *clouds* FORESHOW?

A. When these piles of cloud are *fleecy,* and sail *against the wind,* they indicate *rain;* but when their outline is very *hard,* and they come up *with* the wind, they foretell *fine weather.*

Cum'ulus clouds should be *smaller* towards evening than they are at noon. If they *increase* in size at sun-set, a thunder-storm may be expected in the night.

Q. *What sort of* CLOUDS *are called* STRA'TUS?

A. *Creeping mists,* especially prevalent in a summer's evening: these clouds rise at sun-set *in low damp places;* and are always *nearer the earth,* than any *other* sort of cloud.

Q. *Why are these mists called* STRA'TUS *clouds?*

A. From the Latin word *stra'tus* ("laid low," or "that which lies low").

Q. *What produces* CIRRUS CLOUDS?

A. Moisture in a visible form, deposited in the *higher regions* of the atmosphere by *ascending currents of heated air.*

Q. *What produces* CUM'ULUS CLOUDS?

A. Masses of visible vapour in the act of being carried (by *horizontal currents of air*) from the places where they were *formed,* to other places where they are about to be either *dissolved,* or deposited as falling *rain.*

Q. *What produces* STRA'TUS CLOUDS?

A. Beds of visible moisture, formed by some chilling effects, acting along the *direct surface* of the *earth.*

Q. *How are the* INTERMEDIATE CLOUDS *subdivided?*

A. Into two sorts. 1.—The Cirro Cum'ulus; and 2.—The Cirro-Stra'tus.

Q. *What are* CIRRO-CUM'ULUS CLOUDS?

A. Cirrus clouds springing from a *massy centre;* or *heavy masses of cloud,*

edged with *long streaks,* or (what are called) "*mares' tails.*"

A system of *small round* clouds may be called cirro-cum'ulus.

Q. *What do* CIRRO-CUM'ULUS *clouds generally* FOREBODE?

A. Continued drought, or hot dry weather.

Q. *What are* CIRRO STRA'TUS CLOUDS?

A. They compose (what is generally called) a "*mackarel sky.*" This class of clouds invariably indicates *rain and wind;* hence the proverb—

"Mackarels' scales and mares' tails
Make lofty ships to carry low sails."

Q. *What produces* CIRRO-CUM'ULUS *clouds?*

A. *Cum'ulus* clouds dissolving away into *cirrus* produce the intermediate class, called CIRRO-CUM'ULUS.

Q. *What produces* CIRRO-STRA'TUS *clouds?*

A. *Cirrus* clouds accumulating into *denser* masses produce the intermediate class, called CIRRO-STRA'TUS.

Q. *How are* COMPOUND CLOUDS *sub-divided?*

A. Compound clouds are also sub-

divided into two sorts. 1.—The Cum'ulo-Stra'tus; and 2.—The Nimbus clouds.

Q. *What is meant by* CUM'ULO-STRA'TUS *clouds?*

A. Those clouds, which assume all sorts of *gigantic fancy forms;* such as vast towers and rocks,—huge whales and dragons,—scenes of battle,—and cloudy giants. This class of clouds is the most romantic and strange of all.

Q. *What do the* CUM'ULO-STRA'TUS *clouds* FORETELL?

A. *A change of weather;* either from fine to rain, or from rain to fine.

Q. *What are* NIMBUS CLOUDS?

A. Nimbus is the Latin word for "*clouds which bring a storm:*" All clouds from which *rain falls* are so named.

Q. *By what particular character may the* NIMBUS *(or rain-cloud) be at once* DISTINGUISHED?

A. By the want of a *defined outline:* its edge is gradually shaded off from the *deep grey mass* into *transparency.*

Q. *What* APPEARANCE *takes place in the* CLOUDS, *at the approach of* RAIN?

A. The *cum'ulus* cloud becomes

stationary, and *cirrus streaks settle upon it*, forming cum'ulo-stra'tus clouds; which are *black* at first, but afterwards of a *grey* colour.

Q. *Why do* CLOUDS *gather* ROUND MOUNTAIN TOPS?

A. Because the air (being *chilled* by its contact with the cold mountain-tops) deposits its vapour there, in a *visible form* or cloud.

Q. *What are the* USES *of* CLOUDS?

A. 1st—They act as screens to arrest *the radiation of heat from the earth*;

2ndly—They temper the heat of the *sun's rays*; and

3rdly—They are the great *store-houses of rain.*

Radiation of heat, i. e. the escape of heat, when no *conductor* carries it away.

Q. *Why is* WIND *said to* BLOW UP *the* CLOUDS?

A. Because when a *dry warm* wind travels over seas, it absorbs a large quantity of moisture; some of which it deposits in the *visible form of clouds*, as soon as it reaches a *colder* region of air.

Q. *Why does* WIND *sometimes* DRIVE AWAY *the* CLOUDS?

A. Because when it travels over *dry climes* or *thirsty deserts,* it becomes *so dry,* that it absorbs vapour from the clouds, and *disperses* them.

Q. *What is the* CAUSE *of a* RED SUN-SET?

A. The vapour of the air not being *actually condensed into clouds,* but only on the *point of being condensed;* in which state it bends the *red rays* of the sun *towards the horizon,* where they tint the floating clouds.

Q. *Why is a* RED SUN-SET *an indication of a* FINE DAY *to-morrow?*

A. Because (notwithstanding the cold of sun-set) the vapours of the earth are *not condensed into clouds.* Our Lord referred to this prognostic in the following words: "When it is evening ye say, it will be fair weather, for the sky is red." (Matt. xvi. 2.)

Q. *What is the cause of a coppery* YELLOW SUN-SET?

A. The vapour of the air being *actually condensed into clouds;* in which

case, it refracts the *yellow rays of the sun towards the horizon,* where they tint the mists which are floating there.

Refracts i. e. bends.

Q. *Why do vapours* NOT ACTUALLY CONDENSED *refract* RED *rays, while condensed vapour refracts yellow?*

A. Because the beams of light meet with very little resistance; in consequence of which, those rays are bent down to the eye which require the least refraction, such as red.

See figure on p. 135, where it is evident that the *red* ray, P. A. is less bent than the yellow and blue rays, P. B. P. C.

Q. *Why do* CONDENSED *vapours refract* YELLOW *rays, whereas vapours not actually condensed refract red.*

A. Because the beams of light meet with *more resistance* from the condensed vapour; in consequence of which, those rays are bent down to the eye which are the *most refracted,* such as yellow.

See figure on p. 135, where it is evident that the yellow ray, P. B. is more bent than the red ray, P. A.

Q *Why is a* YELLOW SUN-SET *an indication of* WET?

A. Because it shows, that the vapours

of the air *are already condensed into clouds;* rain, therefore, may be shortly expected.

Q. *What is the cause of a* RED SUN-RISE?

A. Vapour in the upper region of the air *just on the point of being condensed.*

Q. *Why is a* RED *and* LOWERING *sky at* SUN-RISE *an indication of a* WET DAY?

A. Because the higher regions of the air are *laden with vapour,* on the very *point of condensation,* which the rising sun cannot disperse. Hence our Lord's observation, "In the morning (ye say) it will be foul weather to-day, for the sky is red and lowering." (Matt. xvi. 3.)

Q. *Why is a* GREY MORNING *an indication of a* FINE DAY?

A. Because only the air *contiguous to the earth* is damp and full of vapour. There are no vapours in the *higher* regions of the air, to bend down to the eye either the yellow or red rays of any beam of light.

Q. *What difference (in the state of the air) is required, to make a* GREY *and* RED SUN-RISE?

A. In a *grey* sunrise, only that

portion of air *contiguous to the earth is filled with vapour;* all the rest is clear and dry. But in a *red* sunrise the air in the *upper regions* is so full of vapour that the rising sun cannot disperse it.

Q. *Why is a* GREY SUN-SET *an indication of* WET?

A. Because it shows, that the air on the *surface of the earth* is very *damp at sun-set;* which is a plain proof, that the air is *saturated with vapour;* in consequence of which, wet may be soon expected: hence the proverb—

"Evening red and morning grey
Will set the traveller on his way;
But evening grey and morning red
Will bring down rain upon his head."

Q. *The proverb says, "A* RAINBOW *in the* MORNING *is the shepherd's* WARNING:" *Why is it so?*

A. Because a *morning* rainbow must be *always in the west;* and indicates, that bad weather is *on the road to us.*

Q. *Why must a* MORNING RAINBOW *be always in the* WEST?

A. Because the sun is in the *east,* and a rainbow can be formed only when

the clouds (which contain, or are dropping rain) are *opposite* the sun.

Q *Why does a* RAINBOW *in the* WEST *indicate that* BAD WEATHER *is on the road to us?*

A. Because our heavy rains are usually *brought by west or south-west winds;* and, therefore, clouds which reflect the colour of the rainbow *in the west,* are coming up *with the wind,* bringing rain with them.

Q. *The proverb says, "A* RAINBOW *at* NIGHT, *is the shepherd's* DELIGHT:" *Why is it so?*

A. Because a rainbow at *night* is in the *east;* and indicates that bad weather is *leaving us.*

Q. *Why must a* RAINBOW *at* NIGHT *be always in the* EAST?

A. Because the sun is in the *west,* and a rainbow can be formed only when the clouds (which contain, or are dropping rain) are *opposite* the sun.

Q. *Why does a* RAINBOW *in the* EAST *indicate that bad weather is* LEAVING *us?*

A. Because our rain is generally brought by *west* and *south-west* winds; when, therefore, the clouds (which reflect

the rainbow) have been driven from the *west* to the *east*, it is a plain proof that they have already *passed over us*, and are going away.

Q. *What is meant by an* AURORA BOREA'LIS, *or northern light?*

A. A *luminous white cloud* in the *north of the sky* at night-time. Sometimes streaks of blue, purple, and red,—and sometimes flashes of light, are seen also.

In our island this phenomenon generally arises from a dark cloud (running from the north to the east and west) elevated about 10 or 20 degrees above the horizon: above this dark bed of clouds the luminous white light appears.

Q. *What is the cause of the* AURORA BOREA'LIS *or northern light?*

A. *Electricity* in the higher regions of the atmosphere.

Q. *Why is the* AURORA BOREA'LIS *generally a* WHITE *light?*

A. Because the electric fluid passes through air *extremely rarefied:* and whenever electric fluid passes through *air much rarefied*, it always produces a *white light.*

Q *Why are there sometimes* DIFFERENT

COLOURS *in the aurora borea'lis, such as yellow, red, and purple?*

A. Because the electric fluid passes through *air of different densities*. The most *rarefied air* produces a *white light*; the most *dry* air, *red*; and the most *damp* produces *yellow* streaks.

Q. *Does the* AURORA BOREA'LIS *forbode fine weather or* WET?

A. When its *coruscations are very bright*, it is generally followed by stormy moist unsettled weather.

Q. *Why does a* HAZE *round the* SUN *indicate* RAIN?

A. Because the *haze* is caused by *very fine rain falling in the upper regions of the air*; when this is the case, a *rain* of 5 *or* 6 *hours duration*, may be expected.

Q. *Why is a* HALO *round the* MOON *a sure indication of* RAIN?

A. Because it is caused by *fine rain falling in the upper regions of the air*. The *larger* the halo the *nearer the rain-clouds*, and the sooner may rain be expected.

Q. *Why does a* BLACK MIST *bring* WET *weather?*

A. The mist is *black,* because it is *overshadowed by dense clouds* or masses of vapour; in consequence of which, it forebodes wet.

Q. *Why does a* WHITE MIST *indicate* FINE *weather?*

A. The mist is *white,* because *no clouds blacken it with their shadow;* and (as the sky is cloudless) *fine weather* may be expected.

Q. *Why do we* FEEL *almost* SUFFOCATED *in a hot cloudy night?*

A. Because the heat of the earth (being prevented by clouds from escaping into the upper region of the air) *floats,* like a sea of heat, *on the surface of the earth.*

Q. *Why do we feel more* SPRIGHTLY *in a clear bright night?*

A. Because the heat of the earth can readily escape into the upper regions of the air, and is not confined and pent-in *by thick clouds.*

Q. *Why do we* FEEL DEPRESSED *in* SPIRITS *on a* WET *murky* DAY?

A. 1st—Because the air is laden with vapour, and has (proportionally) *less oxygen*.

2ndly—The air being lighter than usual, *does not balance the air in our body:* and

3rdly—Moist air has a tendency to depress the nervous system.

Q. *What is meant by the "air balancing the air in our body?"*

A. The human body contains air of a given density; if, therefore, we ascend into *rarer air*, or descend into *denser*, the balance is destroyed, and *we feel oppressed.*

Q. *Why do we feel* OPPRESSED, *if the air around is not of the* SAME DENSITY, *as that in our body?*

A. If the air around be *more* dense than our body, it will produce a feeling of *oppression:* if it be *less* dense, the air in our body will produce a feeling of *distension.*

Q. *Why do* PERSONS, *who* ASCEND *in* BALLOONS, FEEL PAIN *in their eyes, ears, and chest?*

A. Because the air in the upper regions of the atmosphere, is *more rare*, than the *air in their bodies;* and (till *equilibrium is restored*) great pain will be felt in all the more sensitive parts of the body.

More especially in the tympanum of the ear.

Q. *Why do* PERSONS, *who* DESCEND *in* DIVING-BELLS, FEEL PAIN *in their eyes, ears, and chest?*

A. Because the air in the diving-bell is *compressed* by the upward pressure of the water; in consequence of which, great pain is felt in all the more sensitive parts of the body.

The pressure thus caused is sometimes sufficient to *rupture* the membrane of the tympanum, and produce incurable *deafness.*

Q. *Why are* PEARL DIVERS *very frequently* DEAF?

A. Because the *pressure of the water* against the tympanum of their ears *ruptures* the membrane, which produces incurable deafness.

Q. *Why does the* SEA HEAVE *and* SIGH, *just* PREVIOUS *to a* STORM?

A. Because the density of the air

(just previous to a storm) is *very suddenly diminished,* but the air in the sea is not so quickly affected; therefore, the sea heaves and sighs while *equlibrium* is being *restored.*

Q. *Why is the* AIR *so universally* QUIET, *just* PREVIOUS *to a* TEMPEST ?

A. Because the air is *suddenly and very greatly rarefied;* and (as the density of the air is diminished) its *power to transmit sound* is *diminished also.*

Q. *How do you* KNOW, *that* RAREFIED *air* CANNOT TRANSMIT SOUND, *so well as dense air ?*

A. Because the *sound of a bell* (in the receiver of an air-pump) *cannot be heard at all,* after the air has been partially exhausted; and the report of a pistol (fired on a high mountain) would scarcely be heard.

Q. *Why do we* FEEL BRACED *and* LIGHT-HEARTED *on a* FINE *spring or* FROSTY *morning ?*

A. 1st—Because there is *more oxygen* in the air on a fine frosty morning, than there is on a wet day: and

2ndly—A brisk and frosty air has a tendency to *brace* the nervous system.

Q. *Why do* DOGS *and* CATS *(confined to a room) feel* LAZY *and* DROWSY, *at the approach of rain?*

A. 1st—Because the air does not contain *its full proportion of oxygen:* and

2ndly—The damp *depresses their nervous system,* and makes them drowsy.

Q. *Why do* HORSES *neigh,* CATTLE *low,* SHEEP *bleat, and* ASSES *bray, at the approach of rain?*

A. 1st—As the air does not contain its full proportion of *oxygen,* they feel a *difficulty in breathing:* and

2ndly—As damp *relaxes their nerves,* they feel languid and uneasy.

Q. *Why do* CANDLES *and* FIRES *burn with a* BLUER FLAME *in* WET *weather?*

A. As the air contains *less oxygen* in wet weather, the heat of fire is *less intense:* The flame is *blue,* because the *fuel is not thoroughly consumed.*

Q. *Why do* HILLS, *&c. appear* LARGER *in* WET *weather?*

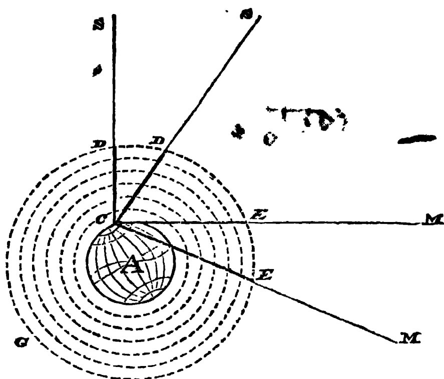
A. Because (when the air is *laden with vapour*) the rays of light are *more dispersed;* in consequence of which, they produce on the eye *larger images of objects.*

Q. *Why do* TREES, *&c. in* WET *weather, appear* FURTHER OFF, *than they really are?*

A. Because the fog or mist *diminishes the light* reflected from the object; and as the object becomes *more dim*, it seems to be *further off*.

Q. *Why does the* SUN *seem* LARGER, *when he* SETS *and* RISES, *than he does at noon?*

A. Because the rays pass through *more of the vapoury atmosphere*, which surrounds the earth; and this vapoury atmosphere acts like a *magnifying glass*.



It is very manifest that the lines D C are shorter than the lines E C: if, therefore, A be the earth, and D G E the boundary of the atmosphere round the earth, then the rays M E C (at the *horizon*) will pass through *more of the atmosphere*, than the rays S D C, which are more elevated.

Q. *Why does the* MOON *appear* LARGER *at her* RISING *and* SETTING, *than when above our heads?*

A. Because the rays pass through *more of the vapoury atmosphere,* which surrounds the earth; and this vapoury atmosphere *magnifies* the moon, as a magnifying-glass would do.

Q. *Why do* CATS RUB *their* EARS, *when it is likely to rain?*

A. Either because the *air is full of vapour,* and its humidity (piercing between the hair of the cat) *produces an itching sensation;* or more probably, because the air is *overcharged with electricity.*

Q. *How can the* ELECTRICITY *of air produce a sensation of* ITCHING?

A. If the *air* is overcharged with electricity, the *hair of the cat* is overcharged also; and this makes her feel, as if she were *covered with cobwebs.*

Q. *Why does the* CAT *keep* RUBBING *herself?*

A. Because her *hair will not lie smooth,* but has a perpetual tendency to become *turgid and ruffled;* so the cat keeps rubbing her coat and ears, to

smooth the hair down, and brush away the feeling of cobwebs.

Q. *Why do our* HEADS *and* SKIN *itch before rain?*

A. Probably because the *air is over-charged with electricity;* and, therefore, a sensation (like that of cobwebs) *irritates the skin,* and produces an itching.

Q. *Why do* DOORS SWELL, *when* RAIN *is at hand?*

A. Because the *air is filled with vapour,* which (penetrating into the pores of the wood) *forces the parts further apart,* and swells the door.

Q. *Why do* DOORS SHRINK *in* DRY *weather?*

A. Because the *moisture is absorbed from the wood;* and, as the particles are *brought closer together,* the size of the door is *lessened,* or (in other words,) the *wood shrinks.*

Q. *Why is the* AIR *filled with offensive* SMELLS, *just previous to a coming* RAIN?

A. Because the volatile parts which rise from dunghills, sewers, &c. are prevented (by the *vapour* of *the air)* from *rising* so readily, as when the sun is shining brightly.

Q. *Why do* FLOWERS *smell* SWEETER *and* STRONGER, *just previous to* RAIN?

A. Because the volatile parts (which constitute the *perfume* of flowers) are prevented (by the vapour of the air) from *rising;* in consequence of which, they are confined to the lower regions of the atmosphere.

N.B. Many essential oils and other volatile substances, which produce odours in plants, require the presence of *much moisture* for their perfect development.

Q. *Why do* HORSES *and other animals stretch out their necks, and* SNUFF *up the* AIR, *just previous to a fall of* RAIN?

A. Because they *smell the odour of plants and hay,* and delight to snuff in their fragrance.

Q. *Why does* SMOKE FALL, *when* RAIN *is at hand?*

A. Because the air (being less *dense* in wet weather) *cannot buoy up smoke* so readily, as when *more dry and heavy.*

Q. *Why do* SWALLOWS FLY LOW, *when* RAIN *is at hand?*

A. Because the *insects* (of which they are in pursuit) *have fled from the cold upper regions of the air,* to the

warm air near the earth: and as their *food is low,* the swallows *fly low.*

Q. *Why do these* INSECTS *seek the lower regions of the air in* WET *weather, more than in* FINE *weather?*

A. Because the *upper* regions of the air are *colder* than the *lower,* in wet weather; and as insects enjoy warmth, they seek it near the earth.

Q. *Why does a* DOWNWARD *current of* COLD AIR *bring* RAIN?

A. Because it *condenses the warm vapour;* which (being condensed) descends in rain.

Q. *The proverb says,* "A SINGLE MAGPIE *in spring,* FOUL WEATHER *will bring:*" *Why is this the case?*

A. Because in cold stormy weather, *one magpie alone* will leave its warm snug nest *in search of food,* while the other stays with the *eggs, or young ones;* but in *fine mild* weather (when their brood will not be injured by cold) *both the magpies fly out together.*

Q. *Why is it* UNLUCKY *for* ANGLERS *to see a* SINGLE MAGPIE *in spring?*

A. Because when *magpies fly abroad singly*, the weather is cold and stormy; but when *both birds fly out together*, the weather is *warm and mild*, which is *favourable for fishing*.

Q. *Why do* SEA GULLS *fly about the* SEA *in* FINE *weather?*

A. Because they *live upon the fishes*, which *are* found near the *surface of the sea in fine weather*.

Q. *Why may we expect* STORMY RAINS, *when* SEA GULLS *assemble on the land?*

A. Because the fishes (on which they live) leave the *surface* of the sea in stormy weather, and are beyond the reach of the *sea-gulls;* in consequence of which, they are obliged to feed on the *worms and larvæ*, which are driven out of the *ground* at such times.

Q. *Why does the* PETREL *fly to the* SEA, *during a storm?*

A. Because the petrel *lives upon sea insects*, which are always to be found in abundance *about the spray of swelling waves*.

N. B. Petrels are birds of the duck-kind, which live

in the open sea. They run on the top of the sea, and are called Petrels, or rather Peter-els, from "St. Peter," in allusion to his walking on the sea, to go to Jesus.

Q. *Why do* CANDLES *and* LAMPS SPIRT, *when* RAIN *is at hand?*

A. Because the *air is filled with vapour,* and the humidity *penetrates the wick;* where (being formed into *steam)* it expands suddenly, and produces a little explosion.

Q. *Why does a* DROP *of* WATER *sometimes* ROLL *along a piece of hot iron without leaving the least trace?*

A. Because (when the iron is *very hot indeed*) the *bottom* of the drop is turned into *vapour,* which *buoys the drop up,* without allowing it to touch the iron.

Q. *Why does it* ROLL?

A. Because the *current of air* (which is always passing over the heated surface) *drives it along.*

Q. *Why does a* LAUNDRESS *put a little* SALIVA *on a* FLAT-IRON, *to know if it be hot enough?*

A. Because when the saliva *sticks* to the box *and is evaporated,* she knows it is *not* sufficiently hot: but when it *runs along the iron,* it is.

Q. *Why is the* FLAT-IRON HOTTER, *if the saliva* RUNS ALONG *it, than if it adheres, till it is evaporated.*

A. Because when the saliva *runs along* the iron, the heat is sufficient to *convert the bottom of the drop* into *vapour;* but if the saliva *will not roll,* the iron is *not* sufficiently hot to convert the bottom of the drop into vapour.

CHAPTER XII.

4.—EVAPORATION.

Q. *What is meant by* EVAPORATION ?

A. The dissipation of liquid by its conversion into *vapour.*

Q. *What* EFFECTS *are produced by evaporation?*

A. The liquid vaporized *absorbs heat* from the body whence it issues; and the body *deprived of the liquid* by evaporation, *loses heat.*

Q. *If you* WET *your* FINGER *in your mouth, and hold it up in the air, why does it* FEEL COLD?

A. Because the saliva quickly *evaporates;* and (as it evaporates) ***absorbs heat from the finger,*** and makes it feel cold.

Q. *If you* BATHE *your* TEMPLES *with ether, why does it allay* INFLAMMATION *and feverish heat?*

A. Ether very rapidly *evaporates;* and (as it evaporates) ***absorbs heat from the burning head,*** producing a sensation of cold.

Q. *Why is* ETHER *better for this purpose than* WATER?

A. Because Ether requires *less heat to convert it into vapour;* in consequence of which, it evaporates more *quickly.*

N.B. Ether is converted into vapour with 104 *degs.* of heat, but water requires 212 *degs.* of heat to convert it into steam.

Q. *Why does* ETHER *very greatly* RELIEVE *a* SCALD *or* BURN?

A. Because it *evaporates very rapidly;* and (as it evaporates) ***carries off the heat of the burn.***

Q. *Why do we* FEEL COLD, *when we have* WET FEET *or* CLOTHES?

A. Because as the wet of our shoes or clothes *evaporates,* it keeps ***absorbing heat from the body,*** which makes it feel cold.

Q. *Why do* WET FEET *or* CLOTHES *give us* "COLD?"

A. Because the evaporation *absorbs heat* so abundantly from the surface of our body, that its temperature is *lowered below its natural standard*; in consequence of which, health is injured.

Q. *Why is it* DANGEROUS *to* SLEEP *in a* DAMP BED?

A. Because the heat is continually absorbed from the surface of our body, to *convert the damp of the sheets into vapour;* in consequence of which, our animal heat is reduced *below the healthy standard.*

Q. *Why is* HEALTH INJURED, *when the* TEMPERATURE *of the* BODY *is* REDUCED *below its natural standard?*

A. Because the *balance of the circulation* is destroyed: Blood is driven away from the *external surface* by the *chill,* and thrown upon the *internal organs,* which are *oppressed* by this increased *load of blood.*

Q. *Why do we not feel the same sensation of cold, if we throw a* MACINTOSH *over our* WET CLOTHES?

A. Because the macintosh (being air

tight) *prevents evaporation*; and (as the *wet cannot evaporate)* no heat is absorbed from our bodies.

Q. *Why do* NOT SAILORS *get* COLD, *who are frequently wet all day with* SEA-WATER?

A. 1st—Because the *salt* of the sea *retards evaporation;* and (as the heat of their body is drawn off *gradually)* the sensation of cold is prevented.

2ndly—The *salt* of the sea acts as a stimulus, and keeps the blood circulating in the skin.

Q. *Why does* SPRINKLING *a* HOT ROOM *with water* COOL IT?

A. Because the heat of the room causes a *rapid evaporation of the sprinkled water;* and as the water evaporates, *it absorbs heat from the room,* and cools it.

Q. *Why does* WATERING *the* STREETS *and roads* COOL THEM?

A. Because the hot streets and roads part with their heat, *to promote the evaporation of the water sprinkled on them.*

Q. *Why does a* SHOWER *of* RAIN COOL *the* AIR *in summer-time?*

A. Because the wet earth *parts with*

its heat to promote evaporation; and when the *earth* is cooled, it *cools the air* also.

Q. *Why is* LINEN DRIED *by being exposed to the* WIND?

A. Because the wind *accelerates evaporation,* by removing the vapour from the *surface of the wet linen,* as fast as it is formed.

Q. *Why is* LINEN DRIED *sooner in the open* AIR, *than in a confined room?*

A. Because the particles of vapour are more rapidly removed from the surface of the linen by evaporation.

Q. *Why are* WET SUMMERS *generally* SUCCEEDED *by* COLD WINTERS?

A. Because the great evaporation (carried on through the wet summer) *reduces the temperature of the earth lower than usual,* and produces cold.

Q. *Why is* ENGLAND WARMER *than it used to be, when* AGUES *were common?*

A. Because it is *better drained* and *better cultivated.*

Q. *Why does* DRAINING *land promote* WARMTH?

A. Because it *diminishes evaporation;* in consequence of which, *less heat* is abstracted from the earth.

Q. *Why does* CULTIVATION *increase the* WARMTH *of a country?*

A. 1st—Because *hedges and belts of trees* are multiplied:

2ndly—The land is *better drained:* and

3rdly—The vast *forests are cut down.*

Q. *Why do* HEDGES *and* BELTS *of* TREES *promote* WARMTH?

A. Because they *retard evaporation,* by keeping off the *wind.*

Q. *If belts of trees promote* WARMTH, *why do* FORESTS *produce* COLD?

A. 1st—Because they *detain and condense the passing clouds:*

2ndly—They prevent the access of both *wind and sun:*

3rdly—The soil of forests is always *covered with long damp grass, rotting leaves, and thick brushwood:* and

4thly—In every forest there are always many hollows *full of stagnant water.*

Q. *Why do* LONG GRASS *and* ROTTING LEAVES *promote* COLD?

A. Because *they are always damp;* and the evaporation which they promote, *is constantly absorbing heat* from the earth beneath.

Q. *Why are* FRANCE *and* GERMANY WARMER *now, than when the vine would not ripen there?*

A. Chiefly because *their vast forests have been cut down;* and the soil is better *drained and cultivated.*

Q *What becomes of the* WATER *of* PONDS *and* TUBS *in summer-time?*

A. Ponds and tubs are often left dry in summer-time, because their water is *evaporated by the air.*

Q. *How is this* EVAPORATION PRODUCED *and carried on?*

A. The heat of the air changes the *surface of the water into vapour,* which (blending with the air) *is soon wafted away;* and *similar evaporation* is repeatedly produced, till the pond or tub is left quite dry.

Q. *Why are the* WHEELS *of some machines kept* CONSTANTLY WET *with* WATER?

A. *To carry off* (by evaporation) *the heat,* which arises from *the rapid motion* of the wheels.

Q. *Why is* MOULD HARDENED *by the* SUN?

A. Because (when the moisture of the mould has been *evaporated by the*

sun) the earthy particles come into *closer contact,* and the mass becomes more solid.

Q. *Show the* WISDOM *of* GOD *in this arrangement?*

A. If the soil did not become *crusty and hard in dry weather,* the heat and drought would *penetrate the soil,* and kill both seeds and roots.

Q. *Why is* TEA *cooled* FASTER *in a* SAUCER, *than in a cup?*

A. Because *evaporation is increased* by *increasing the surface;* and as tea in a saucer presents *a larger surface to the air,* its heat is more rapidly carried off by evaporation.

(The subject of "convection" will be treated of in a future chapter; it would scarcely be understood in this place.)

Q. *Why is not the* VAPOUR *of the* SEA SALT?

A. Because the *salt* is always *left behind,* in the process of evaporation.

Q. *What is that* WHITE CRUST *which appears (in hot weather) upon* CLOTHES *wetted by sea water?*

A. The *salt of the water,* left on the clothes by evaporation.

Q

Q *Why does this* WHITE CRUST *always* DISAPPEAR *in* WET *weather?*

A. Because the *moisture of the air dissolves the salt;* in consequence of which, it is no longer visible.

Q. *Why should* NOT *persons, who take violent exercise,* WEAR *very* THICK CLOTHING?

A. When the heat of the body is increased by exercise, *perspiration reduces the heat* (by evaporation) *to a healthy standard:* as thick clothing *prevents* this evaporation, it is injurious to health.

CHAPTER XIII.

COMMUNICATION OF HEAT.

1.—CONDUCTION.

Q. *How is* HEAT COMMUNICATED *from one body to another?*

A. 1. By Conduction. 2. By Absorption. 3. By Reflection. 4. By Radiation. and 5. By Convection.

Q. *What is meant by* CONDUCTION *of heat?*

A. Heat communicated from one body to another by *actual contact.*

Q. *Why does a* PIECE *of* WOOD *(blazing at* ONE *end)* NOT FEEL HOT *at the* OTHER?

A. Because *wood is so bad a conductor,* that heat does not traverse freely through it: hence, though one end of a stick be blazing, the other end may be quite cold.

Q. *Why do* SOME THINGS *feel* COLDER *than others?*

A. Principally because they are *better conductors:* in consequence of which, they draw off heat from our body much faster.

Q. *What are the* BEST CONDUCTORS *of* HEAT?

A. *Dense solid bodies,* such as metal and stone.

Q. *Which* METALS *are the most* RAPID CONDUCTORS *of* HEAT?

A. The *best* conductors of heat are 1. gold, 2. silver, 3. copper:

The *next* best are 4. platinum, 5. iron, 6. zinc, 7. tin: Lead is a very *inferior* conductor to any of the preceding metals.

Q. *What are the* WORST CONDUCTORS *of* HEAT?

A. All *light and porous bodies;* such as hair, fur, wool, charcoal, and so on.

Q. *Why are* COOKING VESSELS *often furnished with* WOODEN HANDLES?

A. Because wood is *not a good conductor,* like metal; and, therefore, *wooden handles* prevent the heat of the vessel from rushing into our hands, and burning them.

Q. *Why is the* HANDLE *of a* METAL TEA-POT *made of* WOOD?

A. Because *wood is a bad conductor;* therefore, the heat of the boiling water is *not so quickly conveyed* to our hand by a wooden handle, as if it were made of metal.

Q. *Why would a* METAL HANDLE BURN *the* HAND *of the tea-maker?*

A. Because metal is an *excellent conductor;* therefore, the heat of the boiling water *rushes so quickly* into the *metal handle,* that it burns our hand.

Q. *How do you know that a* METAL HANDLE *would be* HOTTER *than a* WOODEN *one?*

A. If we *touch the metal collar* into which the wooden handle is fixed, we shall find that the wooden handle *feels cold,* but the metal collar *intensely hot.*

Q. *Why do persons use paper or* WOOLLEN KETTLE-HOLDERS?

A. Because paper and woollen are both very *bad conductors of heat;* in consequence of which, the heat of the kettle does not *readily pass through them* to the hand.

Q. *Does the heat of the boiling kettle* NEVER *get through the woollen or paper kettle-holder?*

A. Yes; but though the kettle-holder became as hot as the kettle itself, it would never *feel* so hot.

Q. *Why would not the kettle-holder* FEEL *so hot as the kettle, when it really is of the same temperature?*

A. Because (being a very *bad* conductor) it *disposes of its heat too slowly* to be *perceptible;* but metal (being an *excellent* conductor) disposes of its heat *so quickly,* that the sudden influx is painful.

Q. *Why then does* HOT METAL FEEL MORE *intensely* WARM, *than* HOT WOOL?

A. Because metal gives out a much *greater quantity of heat* in the *same space of time;* and the *influx* of heat is, consequently, *more perceptible.*

Q. *Why does* MONEY *in our pocket feel very* HOT, *when we stand* BEFORE *a* FIRE?

A. Because metal (being an *excellent* conductor) becomes rapidly heated: And, for the same reason, it becomes *rapidly cold,* whenever it comes in contact with a body *colder than itself.*

Q. *Why does a* PUMP-HANDLE *feel intensely* COLD *in* WINTER?

A. As metal is an *excellent* conductor, when the hot hand touches the cold pump-handle, the heat passes rapidly *from the hand into the iron;* and this rapid loss of heat produces a sensation of intense coldness.

Q. *Is the iron* HANDLE *of the pump really* COLDER, *than the wooden* PUMP *itself?*

A. No; every inanimate substance (exposed to the same temperature) possesses in reality the *same degree of heat.*

Q. *Why then does the* IRON HANDLE *seem so* MUCH COLDER, *than the* WOODEN PUMP?

A. Merely because the *iron is a better conductor;* and, therefore, *draws off the heat* from our hand more rapidly than wood does.

Q. *Why does a* STONE *or marble* HEARTH *feel to the feet* COLDER, *than a* CARPET *or hearth-rug?*

A. Because *stone* and *marble* are *good* conductors; but *woollen carpets* and *hearth-rugs* are very *bad* conductors.

Q. *How does the* STONE HEARTH *make our* FEET COLD?

A. As soon as the hearth-stone has absorbed a portion of heat from our foot, it instantly disposes of it, and calls for a *fresh supply;* till the hearth-stone has become of the *same temperature, as the foot placed upon it.*

Q. *Do not also the woollen* CARPET *and* HEARTH-RUG *conduct heat from the human body?*

A. Yes; (but woollen being a very *bad* conductor) conveys the heat away *so slowly,* that it is scarcely perceptible.

Q *Is the* COLD HEARTH-STONE *in reality of the* SAME TEMPERATURE *as the* WARM CARPET?

A. Yes; everything in the room is really of *one temperature;* but some feel colder than others, because they are *better conductors.*

Q. *How* LONG *will the hearth-stone feel cold to the feet resting on it?*

A. Till the *feet* and the *hearth-stone* are *both of the same temperature;* and then the sensation of cold in the hearth-stone will go off.

Q. *Why would not the* HEARTH-STONE *feel* COLD, *when it is of the* SAME *temperature as our* FEET?

A. Because the heat would no longer *rush out of our feet into the hearth-stone,* in order to produce an equilibrium.

Q. *Why does the* HEARTH-STONE *(when the fire is lighted) feel* HOTTER *than the* HEARTH-RUG?

A. Because the hearth-stone is an *excellent conductor,* and parts with its heat *very readily;* but the woollen hearth-rug (being a *bad* conductor) parts with its heat very *reluctantly.*

Q. *Why does* PARTING *with* HEAT RAPIDLY *make the* HEARTH-STONE *feel* WARM?

A. As the heat of the stone rushes

quickly into our *feet,* it raises their temperature *so suddenly,* that we cannot *help perceiving the increase of heat.*

Q. *Why does the non-conducting power of the* HEARTH-RUG *prevent its feeling so* HOT *as it really is?*

A. Because it parts with its heat *so slowly and gradually,* that we scarcely *perceive its transmission* into our feet.

Q. *When we plunge our* HANDS *into a basin of* WATER, *why does it produce a sensation of* COLD?

A. Because it is a *better conductor* than air; and as it draws off the heat from our hands more *rapidly,* therefore, it *feels colder.*

Q. *Why does the* CONDUCTING *power of water make it feel* COLDER *than* AIR?

A. Because it *abstracts heat from our hands so rapidly,* that we *feel* its loss; but the air abstracts heat *so very slowly,* that its *gradual loss is hardly perceptible.*

Q. *Is water a* GOOD CONDUCTOR *of heat?*

A. No; *no* liquid is a *good* conductor of heat; but yet water is a *much better conductor* than *air.*

Q. *Why is* WATER *a* BETTER CONDUCTOR *of heat than* AIR?

A. Because *it is less subtile;* and the conducting power of any substance depends upon *its solidity,* or the *closeness of its particles.*

Q. *How do you know, that* WATER *is* NOT *a* GOOD CONDUCTOR *of heat?*

A. Because water may be made to *boil at its surface,* without imparting sufficient heat to *melt ice a quarter of an inch below the boiling surface.*

Q. *Why are* NOT LIQUIDS GOOD CONDUCTORS *of heat?*

A. Because the heat (which should be transmitted) *produces evaporation,* and *flies off in the vapour.*

Q. *Why does a* POKER *(resting on the fender) feel* COLDER *than the* HEARTH-RUG, *which is further off the fire?*

A. Because the poker is an *excellent conductor,* and draws heat from the hand much *more rapidly* than the woollen hearth-rug, which is a very *bad conductor:* though both, therefore, are *equally warm,* the *poker* seems to be the *colder.*

Q. *Why are* HOT BRICKS *(wrapped in cloth) employed in cold weather to* KEEP *the* FEET WARM?

A. Bricks are *bad conductors* of heat, and cloth or flannel *still worse:* in consequence of which, a hot brick (wrapped in flannel) will *retain its heat a very long time.*

Q. *Why is a* TIN PAN *(filled with* HOT WATER) *employed as a* FOOT-WARMER?

A. Because *polished tin* (being a bad radiator of heat) *keeps hot a very long time;* and warms the feet resting upon it.

Q. *What is meant by being a "bad* RADIATOR *of heat?"*

A. To radiate heat is to *throw off heat by rays,* as the sun; a polished tin pan does *not throw off the heat of boiling water* from its surface, but *keeps it in.*

Q. *Why is the* TIN FOOT-WARMER *covered with* FLANNEL?

A. 1st—That the *polish* of the tin may not be injured:

2ndly—Because the flannel (which is a *very bad conductor)* helps to keep the tin hot *longer:* and

3rdly—Lest the conducting surface of the tin should *feel painfully hot* to them.

Q. *What disadvantage would it be, if the* POLISH *of the tin were injured?*

A. If the tin foot-warmer were to *lose its polish,* it would get cold *in a much shorter time.*

Q. *Why would the tin foot-warmer get* COLD SOONER, *if the* POLISH *were* INJURED?

A. Because *polished* tin throws off its heat *very slowly;* but dull, scratched, painted, or dirty tin, *throws off its heat very quickly.*

Q. *Why are* FURNACES *and stoves (where much* HEAT *is required) built of porous* BRICK?

A. Because bricks are bad conductors, and *prevent the escape of heat;* in consequence of which, they are employed where great heat is required.

Q. *Why are* FURNACE DOORS, *&c frequently* COVERED *with a paste of* CLAY *and* SAND?

A. Because this paste is a *very bad conductor of heat;* and, therefore, prevents the *escape of heat from the furnace.*

Q. *If a stove be placed in the* MIDDLE *of a room, should it be made of bricks or* IRON?

A. A stove in the *middle of a room* should be made of *iron;* because iron is an *excellent conductor*, and rapidly communicates its heat to the air around.

Q. *Why does the Bible say, that God "giveth* SNOW *like* WOOL?"

A. Because *snow* (being a *very bad conductor of heat*) protects vegetables and seeds from the frost and cold.

Q. *How does the non-conducting power of* SNOW PROTECT VEGETABLES *from the* FROST *and cold?*

A. It prevents the *heat* of the earth from being *drawn off* by the cold air, which rests upon it.

Q. *Why are* WOOLLENS *and* FURS *used for* CLOTHING *in* COLD *weather?*

A. Because they are *very bad conductors* of heat; and, therefore, *prevent the warmth of the body from being drawn off* by the cold air.

Q. *Do not woollens and furs actually* IMPART *heat to the body?*

A. No; they merely *prevent the heat of the body from escaping.*

Q. *Where would the heat* ESCAPE *to, if the body were* NOT *wrapped in wool or fur?*

A. The heat of the body would *fly off* into the air; for the cold air (coming in contact with our body), would *gradually draw away its heat*, till it was as cold as the air itself.

Q. *What then is the* PRINCIPAL USE *of* CLOTHING *in winter-time?*

A. 1st—To prevent the animal heat from escaping too freely: and

2ndly—To protect the body from the *external air* (or wind), which would carry away its heat too rapidly.

Q. *Why are* BEASTS COVERED *with* FUR, HAIR, *or* WOOL?

A. Because fur, hair, and wool, are very *slow conductors of heat;* and (as dumb animals cannot be clad, like human beings) God has given them *a robe of hair* or wool, to *keep them warm.*

Q. *Why are* BIRDS *covered with* DOWN *or* FEATHERS?

A. Because down and feathers are *very bad conductors of heat;* and (as birds cannot be clad, like human beings)

God has given them *a robe of feathers, to keep them warm.*

Q. *Why are* WOOL, FUR, HAIR, *and* FEATHERS, *such* SLOW CONDUCTORS *of heat?*

A. Because a *great quantity of air* lurks entangled between their fibres; and *air* is a *very bad conductor* of heat.

Q. *If* AIR *be a* BAD CONDUCTOR *of heat, why should we not feel as warm* WITHOUT *clothing, as when we are wrapped in wool and fur?*

A. Because the air (which is cooler than our body) *is never at rest;* and, therefore, fresh particles (perpetually passing over our body) *keep drawing off the heat little by little.*

Q. *How does the ceaseless* CHANGE *of air tend to* DECREASE *the* WARMTH *of a naked body?*

A. Thus:—the air, (which cases the body), absorbs as much heat from it as it can, while it remains in contact; being then blown away, it makes room for a *fresh coat of air,* which absorbs *more* heat.

Q. *Does the* AIR, *which encases a naked body, become (by contact) as* WARM *as the* BODY *itself?*

A. It would do so, if it remained *motionless;* but as it remains only *a very*

short time, it absorbs as much heat as it can in the time, and passes on.

Q. *Why do we feel* COLDER *in* WINDY WEATHER, *than in a* CALM *day?*

A. Because (in windy weather) the particles of air *pass over us more rapidly;* and every *fresh* particle takes from us *some* portion of heat.

Q. *Show the wisdom of God in making the* AIR *a* BAD CONDUCTOR?

A. If air were a *good conductor* (like iron and stone) the heat would be drawn *so rapidly from our body*, that we must be *chilled to death.* Similar evils would be felt also by *all* the animal and vegetable world.

Q. *Does not the bad conducting power of air enable persons to judge, whether an* EGG *be* NEW *or* STALE?

A. Yes; touch the larger end of the shell with your tongue; if it *feels warm* to the tongue, the *egg is stale;* if *not*, it is new-laid.

Q. *Why will the* SHELL *of a* STALE EGG *feel* WARM *to the tongue?*

A. Because the thick end of an egg

always contains *a small quantity of air* (between the shell and the white); when the egg is stale the white *shrinks*, and the *air* accordingly *expands*.

Q. *Why does the expansion of air (at the end of an egg) make it feel* WARM *to the tongue?*

A. As air is a very bad conductor, the more *air* an egg contains, the *less heat will be drawn from the tongue*, when it touches the shell.

Q. *Why will a* NEW-LAID *egg feel* COLDER *to the tongue at the thick end, than a stale one?*

A. Because it contains *more white* and *less air*; and as the *white* of an egg is a better conductor than *air*, the heat of the tongue will be drawn off *more rapidly*, and the egg feel *colder*.

Q. *Why does* FANNING *the face in summer, make it* COOL?

A. Because the fan *puts the air in motion*, and makes it pass more *rapidly over the face;* and (as the temperature of the *air is always lower*, than that of the human *face)* each puff of air *carries off some portion of its heat.*

Q. *Does* FANNING *make the* AIR *itself* COOLER?

A. No; fanning makes the *air hotter and hotter.*

Q. *How does* FANNING *the air increase its* HEAT?

A. By driving it more rapidly over the human body, and causing it, consequently, to *absorb more of its heat.*

Q. *If fanning makes the* AIR HOTTER, *how can it make a* PERSON *feel* COOLER?

A. Fanning makes the *air hotter*, but the *face cooler;* because it takes the heat *out of the face*, and gives it to the *air.*

Q. *Why is* BROTH COOLED *by* BLOWING *it?*

A. Because the breath causes a rapid *change of air* to pass over the broth; and (as the air is not so hot as the broth) it continually *absorbs heat* from it, and makes it cooler and cooler.

Q. *Would not the air absorb heat from the broth just as well* WITHOUT BLOWING?

A. No; *air is a very bad conductor;* unless, therefore, *the change be rapid,* the air nearest the surface of the broth *would soon become as hot as the broth itself.*

Q. *But would not the hot air* PART *with its heat instantly to the* CIRCUMJACENT *air?*

A. No; not instantly. Air is so bad a conductor, *that it parts with its heat very slowly:* unless, therefore, the air be kept in *continual motion*, it would *cool the broth very slowly indeed.*

Q. *Why does* WIND *generally feel* COOL?

A. Wind is only air in motion; and the more quickly the *air passes over our body*, the more rapidly it *absorbs heat* therefrom.

Q. *Why does* AIR ABSORB *heat more* QUICKLY *by being set in* MOTION?

A. Because every fresh gust of air *absorbs a fresh portion of heat;* and the more rapid the *succession of gusts*, the greater will be the quantity of air absorbed.

Q. *If the* AIR *were* HOTTER *than our body, would the* WIND *feel* COOL?

A. No; if the air were *hotter than our body*, it would feel *insufferably hot.*

Q. *Why would the* AIR *feel* INTENSELY HOT, *if it were* WARMER *than our* BODY?

A. Because it would *add* to the heat of our body, instead of *diminishing* it.

Q. *Is the* AIR EVER *as* HOT *as the human* BODY?

A. Not in *this* country: in the hottest summer's day, the air is at least 10 or 12 degrees *cooler than the human body.*

Q. *Is the* EARTH *a good conductor of heat?*

A. No; the earth is a very *bad* conductor of heat.

Q. *Why is the* EARTH *a* BAD *conductor of heat?*

A. Because its particles are not *continuous;* but the power of *conducting* heat depends upon the *continuity of matter.*

Q. *Why is the earth* (BELOW *the* SURFACE) WARMER *in* WINTER, *than the surface itself?*

A. Because the earth is a *bad* conductor of heat; and, therefore, (although the ground be frozen) the frost never penetrates more than a *few inches below the surface.*

Q. *Why is the earth* (BELOW *the* SURFACE) COOLER *in* SUMMER, *than the surface itself?*

A. Because the earth is a *bad* conductor of heat; and, therefore, (although the *surface be scorched* with the burning

sun) the intense heat cannot penetrate to the *roots* of the plants and trees.

Q. *Shew the* WISDOM *of* GOD *in making the* EARTH *a* BAD CONDUCTOR?

A. If the *heat and cold could penetrate the earth* (as freely as the heat of a fire penetrates iron), the springs would be dried up in summer and frozen in winter, and all vegetation would perish.

Q. *Why is* WATER *from a* SPRING *always* COOL, *even in* SUMMER?

A. Because the earth is *so bad a conductor*, that the burning rays of the sun can penetrate only a few inches below the surface; in consequence of which, the *springs of water are not affected* by the heat of summer.

Q. *Why is it* COOL *under a* SHADY *tree in a hot summer's day?*

A. 1st—Because the overhanging foliage *screens off the rays of the sun:*

2ndly—As the rays of the sun are warded off, *the air* (beneath the tree) is not heated by the *reflection of the earth:* and

3rdly—The leaves of trees, being *non-conductors,* allow no heat to penetrate them.

Q. *Why do the* LAPLANDERS *wear* SKINS, *with the* FUR INWARDS ?

A. Because the *dry skin* prevents the *wind* from penetrating to their body ; and the *air* (between the hairs of the fur) soon becomes *heated by the body ;* in consequence of which, the Laplander in his fur is clad in *a case of hot air,* impervious to the *cold* and *wind.*

Q. *Why does a* LINEN SHIRT *feel* COLDER *than a* COTTON ONE ?

A. Because *linen* is a *much better conductor* than cotton ; and, therefore, (as soon as it touches the body) it draws away the heat *more rapidly,* and produces a greater sensation of cold.

Q. *Why is the* FACE COOLED *by wiping the temples with a fine* CAMBRIC HANDKERCHIEF ?

A. Because the fine fibres of the cambric have a *strong capillary attraction for moisture,* and are *excellent conductors* of heat : in consequence of which, the

moisture and heat are *abstracted from the face* by the cambric, and a sensation of coolness is produced.

"Capillary attraction," i. e. *the attraction of a thread or hair.* The wick of a candle is wet with grease, because the melted tallow runs up the cotton from capillary attraction.

Q. *Why would not a* COTTON *handkerchief do as well?*

A. Because the coarse fibres of cotton have very little capillary attraction, and are *very bad conductors:* in consequence of which, the heat of the face would be *increased* (rather than *diminished*) by the use of a *cotton* handkerchief.

CHAPTER XIV.

2.—ABSORPTION OF HEAT.

Q. *What is the difference between* CONDUCTING *heat, and* ABSORBING *heat?*

A. To *conduct* heat, is to *transmit it* from one body to another through a *conducting* medium: To *absorb* heat, is to *suck it up,* as a sponge sucks up water.

Q. *Give me an example.*

A. *Black cloth absorbs,* but does not *conduct heat:* thus, if black cloth be laid in the sun, it will *absorb the rays* very rapidly; but if *one end* of the black cloth be made hot, it would not *conduct* the heat to the *other* end.

Q. *Are good* CONDUCTORS *of heat, good* ABSORBERS *also?*

A. No; every *good conductor* of heat is a *bad absorber* of it; and *no good absorber* of heat can be a *good conductor* also.

Q. *Is* IRON *a good* ABSORBER *of heat?*

A. No; *iron* is a *good conductor,* but a very *bad absorber* of heat.

Q. *Why do the* FIRE-IRONS *(which lie upon a* FENDER) *remain* COLD, *although they are before a good fire?*

A. Because they are *bad absorbers* of heat; in consequence of which, they remain *cold,* unless they come in *contact* with the stove or fire.

Q. *Why are the* FIRE-IRONS *intensely* HOT, *when they* REST AGAINST *the* STOVE, *which contains a good fire?*

A. Because they are *excellent conductors of heat,* and draw it rapidly from the stove with which they are in contact.

Q. *Why does a* KETTLE *boil faster, when the bottom and back are* COVERED *with* SOOT?

A. The *black soot absorbs heat* very quickly from the fire, and the metal *conducts* it to the water.

Q. *Why will not a* NEW KETTLE *boil so fast as an* OLD *one?*

A. Because the *bottom* and *sides* of a new kettle are *clean* and *bright;* but in an *old* kettle they are *covered with soot.*

Q. *Why would a* KETTLE *be* SLOWER A-BOILING, *if the* BOTTOM *and* BACK *were* CLEAN *and bright?*

A. *Bright* metal does *not absorb heat,* but *reflects* it; and (as the heat is *thrown off* from the surface of *bright* metal), therefore, a new kettle is longer boiling.

Reflects heat, i. e. throws it *back* again.

Q. *Why do we wear* WHITE LINEN *and a* BLACK *outer* DRESS, *if we want to be warm?*

A. The *black outer dress* quickly *absorbs heat* from the sun; and the *white linen* (being a *bad* absorbent) abstracts no heat from the warm body.

Q. *Why do persons* WEAR WHITE *dresses in* SUMMER *time?*

A. White *throws off the heat* of the sun by *reflection,* and is, therefore, a very bad absorbent of heat; in consequence of which, it never becomes *so hot from the scorching sun,* as dark colours do.

Q. *Why do* NOT *persons* WEAR WHITE *dresses in* WINTER *time?*

A. Because *white will not absorb heat,* like black and other dark colours; and, therefore, *white dresses are not so warm* as *dark* ones.

Q. *What* COLOURS *are* WARMEST *for dresses?*

A. For *outside* garments *black* is the *warmest,* and then such colours as approach nearest to black (as dark blue and green). *White* is the *coldest colour* for external clothing.

Q. *Why are* DARK COLOURS *(for external wear) so much* WARMER *than* LIGHT ONES?

A. Because *dark colours absorb heat* from the sun more abundantly than *light* ones.

Q. *How can you prove that* DARK *colours are* WARMER *than* LIGHT *ones?*

A. If a piece of *black* cloth and a piece of *white* were laid upon snow, in a few hours the *black cloth will have melted the snow beneath;* whereas the *white* cloth will have produced little or *no effect upon it at all.*

N. B. The *darker* any colour is, the *warmer* it is, because it is a better absorbent of heat. The order may be thus arranged:—1. Black (warmest of all).—2. Violet.—3. Indigo.—4. Blue.—5. Green.—6. Red.—8. Yellow: and 9. White (coldest of all).

Q. *Why are* BLACK KID GLOVES *unpleasantly* HOT *for summer wear?*

A. 1st—Because the *black absorbs the solar heat:* and

2ndly—The *kid* will not allow the heat of the hand *to escape through the glove.*

Q. *Why are* LISLE THREAD GLOVES *agreeably* COOL *for summer wear?*

A. 1st—Because thread *absorbs perspiration:* and

2ndly—It *conducts away the heat* of our hot hands.

Q. *Are Lisle thread gloves* ABSORBENTS *of heat?*

A. As Lisle thread gloves are generally of a *grey or lilac colour,* they do *not absorb solar heat.* s 2

Q. *Why is a* PLATE-WARMER *made of* UNPAINTED BRIGHT TIN?

A. Because bright tin reflects *the heat* (which issues from the fire in rays) upon the meat; and, therefore greatly assists the process of roasting.

Reflects the heat i. e. throws it *back* upon the meat.

Q. *Why would not the tin* REFLECTOR *do as well, if it were* PAINTED?

A. Because it would then *absorb* heat, and *not reflect it at all.* A plate-warmer should never be *painted,* but should be kept *very clean, bright, and free from all scratches.*

Q. *Why should a* REFLECTOR *be kept so very* CLEAN, *and free from all* SCRATCHES?

A. Because, if a reflector were *spotted, dull, or scratched,* it would *absorb* heat, instead of *reflecting* it; and, consequently, would be of no use whatsoever as a *reflector.*

Q. *Why does* HOAR-FROST *remain on* TOMB-STONES, *long after it has melted from the* GRASS *and* GRAVEL-WALKS *of a church-yard?*

A. Because tomb-stones (being *white*), will *not absorb heat,* like the darker grass

and gravel; in consequence of which, they remain too *cold* to thaw the frost congealed upon their surface.

Q. *If black absorbs heat, why have those who live in* HOT *climates* BLACK SKINS, *and not* WHITE *skins, which would not absorb heat at all?*

A. Though the black skin of the negro *absorbs heat* more plentifully than the *white skin of a European,* yet the *blackness* prevents the sun from *blistering* or *scorching it.*

Q. *How is it known, that the* BLACK *colour prevents the sun from either* BLISTERING *or* SCORCHING *the skin?*

A. If you put a *white glove* on *one hand,* and a *black glove* on *the other* (when the sun is burning hot), the hand with the *white* glove will be *scorched,* but *not the other.*

Q. WHICH *hand will* FEEL *the* HOTTER?

A. The hand with the *black glove* will *feel* the *hotter,* but it will not be *scorched* by the sun; whereas the hand with the *white* glove (though much *cooler*) will be *severely scorched.*

Q. *Why does the* BLACK *skin of a* NEGRO NEVER SCORCH *or* BLISTER *with the hot sun?*

A. Because the *black colour absorbs* the heat,—conveys it *below the surface* of the skin,—and converts it to *sensible heat* and *perspiration.*

Q. *Why does the* WHITE EUROPEAN SKIN BLISTER *and* SCORCH, *when exposed to the hot sun?*

A. Because the *white will not absorb* the heat; and, therefore, the hot sun *rests on the surface of the skin, and* scorches it.

Q. *Why has a* NEGRO BLACK EYES?

A. The black colour of a negro's eyes defends them from the strong light of the tropical sun. If a negro's eyes were not *black,* the sun would *scorch them,* and every negro would be blind.

Q. *Why is* WATER *(in hot weather)* KEPT COOLER *in a* BRIGHT TIN POT, *than in an* EARTHEN *one?*

A. Because bright metal will *not absorb* heat from the hot air, like an *earthen* vessel; in consequence of which, the water is kept *cooler.*

Boiling water is also kept *hot* in bright metal better than in earthern vessels. *see p.* 208.

CHAPTER XV.

3.—REFLECTION OF HEAT.

Q. *What is meant by* REFLECTING HEAT?

A. To reflect heat, is *to throw it back in rays* from the surface of the reflecting body, towards the place whence it came.

Q. *What are the* BEST REFLECTORS *of heat?*

A. All *bright* surfaces, and *light colours.*

Q. *Are* GOOD ABSORBERS *of heat* GOOD REFLECTORS *also?*

A. No; those things which *absorb* heat *best, reflect* heat *worst;* and those which *reflect* heat *worst, absorb* it *best.*

Q. *Why are those things which* ABSORB HEAT, *unable to* REFLECT *it?*

A. Because, if any thing *sucks in heat* like a sponge, it cannot *throw it off* from its surface; and if any thing *throws off heat* from its surface, it cannot *drink it in.*

Q. *Why are* REFLECTORS *always made of* LIGHT-COLOURED *and highly* POLISHED METAL?

A. Because *light* coloured and *highly polished metal* makes the best of all reflectors.

Q. *Why do not* PLATE-WARMERS BLISTER *and scorch the* WOOD *behind?*

A. Because the bright tin front throws the heat of the fire *back again,* and will not allow it to penetrate to the wood behind.

Q. *If metal be such an excellent* CONDUCTOR *of heat, how can it* REFLECT *heat, or throw it off?*

A. Polished metal is a *conductor of heat,* only when that heat is communicated by *actual contact;* but whenever heat falls upon bright metal *in rays,* it is *reflected back again,* and the metal remains *cool.*

Q. *What is meant "by heat falling upon metal* IN RAYS," *and not "by contact"?*

A. If a piece of metal were thrust *into* a fire, it would be *in actual contact with the fire;* but if it were *held before a fire,* the heat of the fire would fall upon it *in rays.*

Q. *What is the use of the* TIN SCREEN *or* REFLECTOR, *used in* ROASTING?

A. The tin reflector *throws the heat of the fire back upon the meat;* and, therefore, assists the *process of roasting,* and helps to *keep the kitchen cool.*

Q. *How does a tin* REFLECTOR *tend to keep the* KITCHEN COOL?

A. Because it *confines the heat to the hearth,* and prevents it from being dispersed throughout the kitchen.

Q. *Why are* SHOES HOTTER *for being* DUSTY?

A. 1st—Because dust absorbs heat: and

2ndly—It destroys the *blackness of our shoes;* and, therefore, prevents them from *throwing off the heat of our feet in rays.*

Q. *Why does it always* FREEZE *on the* TOP *of a* MOUNTAIN?

A. 1st—Because the air is very *rarefied;* and *rarefied* air retains more heat in the *latent* form, than *denser* air does: and

2ndly—Air is heated by the *reflection of the earth,* and not by the solar rays; therefore, a mountain-top (which is *deprived* of this reflection) remains intensely cold.

CHAPTER XVI.

4.—RADIATION.

Q. *What is meant by* RADIATION?

A. Radiation means *the emission of rays:* thus the sun radiates both light and heat; that is, it emits *rays of light and heat* in all directions.

Q. WHEN *is heat* RADIATED *from one body to another?*

A. When the two bodies are *separated* by a *non-conducting medium:* thus the sun *radiates* heat towards the earth, because the *air* (which is a very bad conductor) *comes between.*

Q. *On* WHAT *does* RADIATION DEPEND?

A. On the *roughness* of the radiating surface: thus, if metal be *scratched,* its radiating power is increased; because the *heat has more points to escape from.*

Q. *Does a* FIRE RADIATE *heat?*

A. Yes; and because *burning fuel emits rays of heat,* therefore we *feel warm* when we stand before a fire.

Q. *Why does our* FACE FEEL *uncomfortably* HOT, *when we approach a* FIRE ?

A. Because the fire radiates heat upon the face; which (not being *covered*) feels the effect immediately.

Q. *Why does the fire catch the* FACE *more, than it does the* REST *of the body?*

A. Because the *rest* of the body is *covered* with clothing, which (being a *bad conductor* of heat) prevents the same sudden and rapid transmission of heat to the skin.

Q. *Do those substances which* RADIATE *heat,* ABSORB *heat also?*

A. Yes. Those substances which *radiate most*, also *absorb most heat:* and those which *radiate least*, also *absorb the least* heat.

Q. *Does any thing* ELSE *radiate heat,* BESIDES *the* SUN *and* FIRE ?

A. Yes; *all* things radiate heat in *some* measure, but *not equally well.*

Q. WHAT *things* RADIATE *heat the* NEXT BEST *to the sun and fire?*

A. All *dull* and *dark* substances are *good radiators* of heat; but all *light* and

polished substances are *bad radiators* of heat.

Q. *Why should the* FLUES *(connected with Arnott's stoves, &c.) be always* BLACKENED *with* BLACK LEAD ?

A. In order that the heat of the flue may be more readily *diffused* throughout the room. Black lead radiates heat more freely, than any other known substance.

Q. *Why does a* POLISHED METAL TEA-POT *make* BETTER TEA, *than a black earthen one ?*

A. As polished metal is a very *bad radiator* of heat, it *keeps the water hot much longer ;* and the hotter the water is, the better it "draws" the tea.

Q. *Why will not a* DULL BLACK TEA-POT *make good tea ?*

A. Because the heat of the water *flies off so quickly* through the dull black surface of the tea-pot, that the water is very *rapidly cooled,* and cannot "draw" the tea.

Q. *Do not pensioners, and aged cottagers, generally prefer the little* BLACK EARTHEN TEA-POT *to the bright* METAL *one ?*

A. Yes; because they *set it on the*

hob "to draw;" in which case, the little *black tea-pot* will make the *best* tea.

Q. *Why will a* BLACK TEA-POT *make better tea than a bright metal one, if it be set upon the* HOB *to* DRAW?

A. Because the black tea-pot will *absorb heat plentifully* from the fire, and keep the water *hot:* whereas, a bright *metal* tea-pot (set upon the hob) would *throw off* the heat by *reflection.*

Q. *Then sometimes a* BLACK EARTHEN *tea-pot is the best, and sometimes a bright* METAL *one.*

A. Yes; when the tea-pot is *set on the hob "to draw,"* the black *earth* is the *best,* because it *absorbs heat:* but when the tea-pot is *not* set on the hob, the bright *metal* is the *best,* because it *radiates heat very slowly,* and therefore *keeps the water hot.*

Q. *Why does a* SAUCEPAN, *which has been* USED, *boil in a shorter time than a* NEW ONE?

A. Because the bottom and back are *covered with soot;* and the *black soot* rapidly *absorbs the heat* of the glowing coals.

Q. *Why should the* FRONT *and* LID *of a* SAUCEPAN *be clean and* BRIGHT?

A. As they do not come in contact with the fire, they cannot *absorb heat;* and (being bright) they will not suffer the heat to *escape* by radiation.

Q. *In what state should a* SAUCEPAN *be, in order that it may* BOIL QUICKLY?

A. All those parts which *come in contact with the fire* should be covered with *soot,* to absorb heat; but all the *rest* of the saucepan should be as *bright* as possible, to prevent the *escape* of heat by radiation.

Q. *Why is it said, that* "SATURDAY'S KETTLE BOILS *the* FASTEST"?

A. Because, on Saturday, the *front* and *top* of the kettle are generally *cleaned* and *polished;* but the *bottom* and *back* of the kettle are *never* cleaned.

Q. *Why should* NOT *the* BOTTOM *and* BACK *of a kettle be* CLEANED *and polished?*

A. Because *they come in contact with the fire,* and (while they are covered with black soot) *absorb heat freely* from the burning coals.

Q. *Why should the* FRONT *and* TOP *of a kettle be* CLEAN *and well polished?*

A. Because polished metal *will not radiate heat;* and, therefore, (while the front and top of the kettle are well polished) *the heat is kept in,* and not suffered to escape by radiation.

Q. *Why is the* BOTTOM *of a* KETTLE *nearly* COLD, *when the* WATER *is* BOILING HOT?

A. Black soot is a very *bad conductor of heat;* and, therefore, the heat of the boiling water is some time before it gets *through the soot,* which adheres to the bottom of the kettle.

Q. *Why is the* LID *of a* KETTLE *intensely* HOT, *when the water boils?*

A. Because the bright metal lid of the kettle *is an admirable conductor* of heat; and, therefore, *the heat from the boiling water pours into our hand* the moment we touch it.

Q. *Show the benefit of* SMOKE *in* COOKING.

A. The carbon of the fuel (which flies off in smoke) naturally *blackens* all culinary vessels set upon the fire to boil, and thus renders them fit for use.

"Culinary vessels" are vessels used in kitchens for cooking, as saucepans, boilers, kettles, &c.

Q. *How does* SMOKE *make culinary vessels* FIT *for* USE?

A. If it were not for the *smoke* (which gathers round a kettle or saucepan) *heat would not be absorbed,* and the process of boiling would be greatly retarded.

Q. *Why is boiling water* KEPT HOT *in a* BRIGHT METAL *pot, better than in an earthen vessel?*

A. Because bright metal (being a *bad radiator)* will not *throw off from its surface* the heat of the boiling water.

Q. *Would a metal pot serve to keep water hot, if it were* DULL *and* DIRTY?

A. No. It is the bright *polish* of the metal, which makes it a bad radiator; if it were *dull, scratched,* or *dirty,* the heat would *escape* very rapidly.

Water in hot weather is also kept *cooler* in bright metal, than in *dull* or earthen vessels. *see p.* 198.

Q. *Why are* DINNER-COVERS *made of* BRIGHT TIN *or* SILVER?

A. Because light-coloured and highly-polished metal *is a very bad radiator of heat;* and, therefore, bright tin or silver will not allow the heat of the cooked food *to escape through the cover by radiation.*

Q. *Why should a* MEAT-COVER *be very brightly* POLISHED?

A. If the cover be *dull or scratched* it will *absorb heat from the hot food beneath it;* and (instead of keeping it *hot)* will make it *cold.*

Q. *Why should a* SILVER MEAT-COVER *be* PLAIN, *and not* CHASED?

A. Because, if the cover be *chased*, it will *absorb the heat of the food;* and instead of *keeping it hot*, will *make it cold.*

Q. *What is* DEW?

A. Dew is the *vapour of the air condensed*, by coming in contact with bodies *colder than itself.*

Q. *Why is the* GROUND *sometimes* COVERED *with* DEW?

A. Because the surface of the earth (at sun-set) is made so very *cold* by radiation, that the warm vapour of the air is *chilled* by contact with it, and condensed into dew.

Q. *Why is the* EARTH *made colder than the* AIR, *after the sun has set?*

A. Because the *earth radiates* heat very freely, but the air does not; in

consequence of which, it is often 5 or 10 degrees colder (after sun-set); although it was very much *warmer* than the air, during the whole day.

Q. *Why is the* EARTH WARMER *than the* AIR, *during the day?*

A. Because the earth *absorbs* solar heat very freely, but the air does not; in consequence of which, it is often many degrees warmer than the air, during the day.

Q. *Why is the surface of the* GROUND COLDER *in a* FINE *clear* NIGHT, *than in a* CLOUDY *one?*

A. Because, on a fine clear star-light night, *heat radiates from the earth freely,* and is lost in open space: but on a *dull* night, the clouds *arrest the process of radiation.*

Q. *Why is* DEW *deposited only on a* FINE *clear* NIGHT?

A. Because the *surface of the ground radiates heat most freely* on a fine night; and (being cooled down by this loss of heat) *chills the vapour of the air into dew.*

Q. *Why is there* NO DEW *on a dull* CLOUDY NIGHT?

A. Because the clouds *arrest the radiation of heat from the earth;* and (as the heat cannot freely escape) the surface is not sufficiently cooled down, *to chill the vapour of the air into dew.*

Q. *Why is a* CLOUDY NIGHT WARMER *than a* FINE *one?*

A. Because the clouds *prevent the radiation of heat from the earth;* in consequence of which, the surface of the earth remains *warmer.*

Q. *Why is* DEW *most* ABUNDANT *in situations most* EXPOSED?

A. Because the radiation of heat *is not arrested* by houses, trees, hedges, or any other thing.

Q. *Why is there scarcely any* DEW *under a shady* TREE?

A. 1st—Because the shady head of the tree *arrests the radiation of heat from the earth:* and

2ndly—It radiates some of its own heat *towards the earth;* in consequence of which, the ground (underneath a tree) *is not sufficiently cooled down* to chill the vapour of the air into dew.

Q. *Why is there never much* DEW *at the foot of* WALLS *and* HEDGES?

A. 1st—Because they act as screens, *to arrest the radiation of heat from the earth:* and

2ndly—They themselves *radiate some portion of heat* towards the earth; in consequence of which, the ground at the foot of walls and hedges is not sufficiently *cooled down,* to chill the vapour of the air into dew.

Q. *Why is there little or* NO DEW *beneath a* FLOWER-AWNING, *although that awning be open on all four sides?*

A. 1st—Because the awning *arrests* the radiation of heat from the *ground* beneath: and

2ndly—It *radiates* some of its own heat *downwards;* in consequence of which, the ground beneath an awning is *not sufficiently cooled down,* to chill the vapour of air into dew.

Q. *How can a thin covering of* BASS *or even* MUSLIN *protect trees from* FROST?

A. Because *any covering* prevents the radiation of heat from the tree; and

if the tree be *not cooled down* by radiation, the vapour of the air will *not be frozen,* as it comes in contact with it.

Bass *pronounce* bas—a kind of matting used by gardeners.

Q. *Why is the* BASS *or* CANVASS *itself (which covers the tree) always* DRENCHED *with* DEW?

A. Because it *radiates heat* both *upwards* and *downwards;* in consequence of which, it is *so cooled down,* that it readily *chills the vapour* of the *air* into *dew.*

Q. *Why does* SNOW *(at the foot of a* HEDGE *or* WALL*) melt sooner, than that in an open field?*

A. Because the hedge or wall *radiates heat into the snow beneath,* which melts it.

Q. *Why is there* NO DEW *after a* WINDY NIGHT?

A. 1st—Because the wind *evaporates the moisture,* as fast as it is deposited: and

2ndly—It *disturbs* the *radiation of heat;* and thus diminishes the deposition of dew.

Q. *Why are* VALLEYS *and* HOLLOWS *often thickly covered with* DEW, *although they are sheltered?*

A. Because the surrounding hills prevent the *repose* of air from being *disturbed;* but do not *overhang* and *screen* the valleys sufficiently to *arrest* their radiation.

Q. *Why does* DEW FALL *more* ABUNDANTLY *on* SOME THINGS, *than on* OTHERS?

A. Because some things radiate heat *more freely* than others; and, therefore, become *much cooler* in the night.

Q. *Why are things, which* RADIATE HEAT MOST FREELY, *always the most* THICKLY COVERED *with* DEW?

A. Because the vapour of the air is *chilled into dew,* the moment it comes in contact with them.

Q. WHAT *kind of things* RADIATE HEAT *most* FREELY?

A. Grass, wood, and the leaves of plants, radiate heat *very freely:* but polished metal, smooth stones, and woollen cloth, part with their heat *very tardily.*

Q. *Do the leaves of* ALL *plants radiate heat* EQUALLY WELL?

A. No. Rough *woolly leaves* (like

those of a holly-hock) radiate heat much *more freely*, than the *hard smooth polished leaves* of a common laurel.

Q. *Shew the* WISDOM *of* GOD *in making grass, the leaves of trees, and* ALL VEGETABLES, EXCELLENT RADIATORS *of heat?*

A. As vegetables *require much moisture,* and would often *perish* without a plentiful deposit of dew, God wisely made them to *radiate heat freely,* so as to *chill the vapour* (which touches them) *into dew.*

Q. *Will polished* METAL, *smooth* STONES, *and woollen* CLOTH, *readily collect* DEW?

A. No. While grass and the leaves of plants *are completely drenched with dew,* a piece of *polished metal,* or of *woollen cloth* (lying on the same spot), will be *almost dry.*

Q. *Why would* POLISHED METAL *and* WOOLLEN CLOTH *be* DRY, *while grass and leaves are drenched with* DEW?

A. Because the polished metal and woollen cloth *part with their heat so slowly,* that the vapour of the air is *not chilled into dew,* as it passes over them.

Q. *Why is a* GRAVEL WALK *almost* DRY, *when a grass plat is covered thick with* DEW?

A. Because *grass (being a good radiator)* throws off its heat very *freely;* but *gravel (being a very bad radiator)* parts with its heat very slowly.

Q. *Is that the reason why* GRASS *is* SATURATED *with* DEW, *and the* GRAVEL *is* NOT?

A. Yes. When the vapour of warm air comes in contact with the *cold grass,* it is instantly chilled into dew; but (as the gravel is *not so cold as the grass)* the vapour of air is *not so freely condensed,* as it passes over the gravel.

Q. *Why does* DEW *rarely fall upon hard* ROCKS *and* BARREN *lands?*

A. Because rocks and barren lands are so *compact* and *hard,* that they can neither *absorb nor radiate much heat;* and (as their *temperature varies but very little)* very little *dew* distils upon them.

Q. *Why does* DEW *fall more abundantly on* CULTIVATED *soils, than on* BARREN *lands?*

A. Because cultivated soils (being *loose and porous) absorb* heat freely during the day, and *radiate it* by night;

A. Because it supplies it with *moisture* containing carbonic acid; which penetrates slowly into the soil, and insinuates itself through every clod, ridge, and furrow.

Q. *Why is there* NO SNOW *in* SUMMER *time?*

A. No snow reaches the general surface of the earth in summer time, because the *heat of the earth* melts it in its descent.

Q. *Why are some* MOUNTAINS ALWAYS COVERED *with* SNOW?

A. 1st—Because the *air* is more *rarefied;* and rarefied air *abstracts heat,* which it holds in a *latent state:* and

2ndly—As the mountain top is *not surrounded by earth,* to radiate heat into the air; therefore, the snow is *not melted* in its descent, but falls on the mountain, and lies there.

Q. *Why is* SNOW WHITE?

A. Snow is formed of an infinite number of very minute crystals and prisms, which reflect all the colours of the rays of light; and these colours *uniting* before they meet the eye, cause snow to appear white.

Q. *What is* HAIL?

A. Rain, which has passed in its descent *through some cold bed of air,* and has been frozen into drops of ice.

Q. *Why is* ONE *bed of air* COLDER *than another?*

A. This is frequently caused by *electricity unequally distributed* in the air.

Q. *Why is* HAIL *frequently accompanied with* THUNDER *and* LIGHTNING?

A. 1st—Because the *congelation of water into hail* disturbs the electricity of the air: and

2ndly—The *friction* (produced by the fall of hail) excites it still more.

Q. *Why does* HAIL *fall generally in* SUMMER *and* AUTUMN?

A. 1st—Because the air is *more highly electrified* in summer and autumn: and

2ndly—The vapours (being rarefied) ascend to more elevated regions, where the *cold is greater* than it is nearer the earth.

Q. *What* TWO *things are essential to cause* HAIL?

A. Two *strata of clouds* having *opposite electricities*, and *two currents of wind*. The *lower cloud* (being negative) is the one *precipitated*.

Q. *What is* RAIN?

A. The vapour of the clouds or air *condensed*, and precipitated to the earth.

Q. WHY *is the vapour of the air or clouds* PRECIPITATED?

A. When the air is *saturated with vapour*, if a cold current *condenses* it, it is no longer able to hold all its vapour in solution, and some of it falls as rain.

Q. *Why does* RAIN *fall in* DROPS?

A. The vapoury particles in their descent *attract each other;* and those which are sufficiently near, *unite* and form into a drop.

Q. *Why does not the* COLD *of* NIGHT ALWAYS *cause rain?*

A. Because when the air is not near saturation, it will be able to hold its vapour in solution, even after it is condensed by the chilly night.

Q. *Why does a* PASSING CLOUD *often drop* RAIN?

A. Because the cloud (travelling about on the wind) comes into contact with *something that chills it;* and its vapour being condensed, *falls to the earth* as *rain.*

Q. *Why are* RAIN-DROPS *sometimes much* LARGER, *than at* OTHER *times?*

A. When the rain-cloud is floating *near the earth,* the drops are large, because such a cloud is much more *dense,* than one which is more elevated.

The size of the rain drop is increased, according to the *rapidity* with which the vapours are condensed.

Q. *Does not* WIND *sometimes* INCREASE *the* SIZE *of rain-drops?*

A. Yes; by blowing two or more drops into one.

Q. *Why do* CLOUDS FALL *in* RAINY *weather?*

A. 1st—Because the clouds are *heavy* with abundant vapour: and

2ndly—As the density of the air is *diminished,* it is less able to buoy the clouds up.

Q *How do you* KNOW, *that the* DENSITY *of the air is* DIMINISHED *in* RAINY *weather?*

A. Because the mercury of a barometer *falls* in rainy weather.

Q. *Why is* RAIN-*water more* FERTILIZING, *than* PUMP-*water?*

A. Because it contains more carbonic acid, and also a small quantity of *ammonia*, with which it supplies the young plants.

It is probable that the ammonia of rain-water is merely that which escapes from decaying vegetable matters, beaten back by the force of the shower.

Q. *Why does* RAIN PURIFY *the* AIR?

A. 1st—Because it *beats down* the *noxious exhalations* collected in the air, and *dissolves* them:

2ndly—It mixes the air of the *upper* regions with that of the *lower regions:* and

3rdly—It *washes the earth,* and sets in motion the stagnant contents of sewers and ditches.

Q. *Why are* MOUNTAINOUS *countries more* RAINY, *than flat ones?*

A. Because the air (striking against the sides of the mountains) is *carried up the inclined plane,* and brought in contact with the *cold air* of the higher regions; in consequence of which, its vapour is *condensed,* and deposited in rain.

Q. *Why does a* SPONGE SWELL, *when it is* WETTED?

A. Because the water *penetrates the pores* of the sponge by capillary attraction, and drives the particles *further from each other;* in consequence of which, the *bulk* of the sponge is greatly *increased.*

Q. *Why do* FIDDLE-*strings* SNAP *in* WET *weather?*

A. Because the moisture of the air (penetrating the string) causes it to *swell;* and (as the cord *thickens)* its *tension is increased,* and the string snaps.

Q. *Why does* PAPER PUCKER, *when it is* WETTED?

A. Because the moisture (penetrating the paper) *drives its particles further apart;* and (as the moisture is absorbed *unequally* by the paper) some parts are more enlarged than others; in consequence of which, the paper *blisters* or *puckers.*

Q. *Why do the weather-toys (called* CAP'UCHINS) *lift the cowl over the figures in wet weather, and remove it in dry?*

A. The cowl of the cap'uchin is

attached to a *piece of cat-gut* in such a manner, that when the cat-gut is *shortened by moisture,* it pulls the cowl *up;* but in *dry* weather, the *string is loosened,* and the cowl falls down by its own weight.

Q. *In another weather-toy, the* MAN *comes out in* WET *weather, and the* LADY *in* FINE:—*Why is this?*

A. The two figures are attached to a piece of *cat-gut* in such a manner, that when the cat-gut is *shortened by moisture,* it pulls the *man out;* but when it is *loose,* the *woman falls out* by her own weight.

Q. *Why are* WET STOCKINGS DIFFICULT *to* PULL ON?

A. The moisture penetrates the threads of the stockings, and causes them to *shrink in size.*

Q. *What is the* MOST RAINY *spot in* ENGLAND?

A. Keswick (in Cumberland); and then Kendal, (a market town in Westmoreland).

In Keswick, about 63 inches of rain fall in a year. In Kendal, 58; Manchester, 38; Liverpool, 34: Dublin and Cambridge, 25; Lincoln, 24; London, 21; and in Paris, only 18.

Q. *In which* PART *of the* DAY *does the* MOST RAIN *fall?*

A. More rain falls by *night*, than by day; because the cold night *condenses the air*, and diminishes its capacity for holding vapour in solution.

Q. *Does more rain fall in* SUMMER *or in* WINTER *time?*

A. There are *more rainy days* from September to March; but *heavier* rains between March and September.

Q. *Why are there* MORE RAINY DAYS *from September to March, than from March to September?*

A. Because the temperature of the air is *constantly decreasing*, and its capacity for vapour decreases also; in consequence of which, it is perpetually obliged to part with some of its vapour in rain.

Q. *In what* PART *of the* WORLD *does* RAIN *fall* MOST ABUNDANTLY?

A. Near the *equator;* and the quantity of rain *decreases*, as we approach the *poles*.

Q *Why does* MORE RAIN *fall at the* EQUATOR, *than at the* POLES?

being, therefore, *much cooled by this rapid radiation of heat*, they plentifully *condense into dew* the vapour of the passing air.

Q. *Shew the* WISDOM *of* GOD *in this arrangement.*

A. Every plant and inch of land, which *needs* the moisture of dew, is adapted to *collect* it; but *not a single drop* even of *dew* is *wasted*, where its refreshing moisture is *not required.*

Q. *Shew the* WISDOM *of* GOD *in making polished* METAL *and woollen* CLOTH BAD RADIATORS *of heat.*

A. If polished metal collected dew as easily as grass, it could *never be kept dry*, and *free from rust*. Again, if woollen garments collected dew as readily as the leaves of trees, we should be *often soaking wet*, and subject to *constant colds.*

Q. *Shew how this affords a beautiful illustration of* GIDEON'S MIRACLE, *recorded in the book of Judges*, VI. 37, 38.

A. The *fleece of wool* (which is a very *bad* radiator of heat) was soaking *wet* with dew; when the *grass* (which is a most *excellent* radiator) was *quite dry.*

Q. *Was not this* CONTRARY *to the laws of* NATURE ?

A. Yes; and was, therefore, a plain *demonstration* of the *power of God,* who could change the very *nature of things* at his will.

Q. *Why do our* CLOTHES FEEL DAMP, *after walking in a fine evening in* SPRING *or* AUTUMN ?

A. Because the vapour (condensed by the cold earth) lights upon them, like dew.

Q. *Why are* WINDOWS *often covered with thick* MIST, *and the frames wet with standing* WATER ?

A. Because the temperature of the *external air* always *falls* at sun-set, and *chills* the *window-glass,* with which it comes in contact.

Q. *How does this account for the* MIST *and* WATER *on a* WINDOW ?

A. As the warm vapour of the room *touches* the *cold glass,* it is *chilled* and *condensed* into *mist;* and the mist (collecting into drops) *rolls down* the window-frame in little streams of water.

Q. *Does the* GLASS *of a window* COOL *down more* RAPIDLY, *than the* AIR *of the room itself?*

A. Yes; because the air is *kept warm by fires*, and the *animal heat* of the people in the room; in consequence of which, the air of a room suffers *very little* diminution of heat from the setting of the sun.

Q. *Whence arises the* VAPOUR *of a* ROOM ?

A. 1st—The very *air* of the room contains *vapour*:

2ndly—The *breath* and *insensible perspiration* of the inmates *increase* this vapour: and

3rdly—*Hot dinners*, the *steam of tea*, and so on, *increase it* still more.

Q. *What is meant by "the* INSENSIBLE PERSPIRATION"?

A. From every part of the human body, an *insensible* and *invisible perspiration issues* all night and day; not only in the hot weather of *summer*, but also in the coldest day of *winter*.

Q. *If the perspiration be both* INSENSIBLE *and* INVISIBLE, *how is it* KNOWN *that there* IS *any such perspiration?*

A. If you put your naked arm into a *clean dry glass tube*, the *perspiration*

of your arm will soon *condense* on the glass, like mist.

Q. *Why are* CARRIAGE WINDOWS *very* SOON *covered with thick* MIST ?

A. Because the warm vapour of the carriage is *condensed* by the *cold glass*, and covers it with a thick mist.

Q. WHY *is the glass window* COLD *enough, to condense the vapour of the carriage ?*

A. Because the *inside* of the carriage is much *warmer* than the *outside ;* and the glass window is made cold by contact with the *external air.*

Q. WHERE *does the* WARM *vapour of the carriage come from ?*

A. The warm *breath* and insensible *perspiration* of the persons riding, load the air of the carriage with warm vapour.

Q. *What is the cause of the pretty* FROST-WORK, *seen on bed-room* WINDOWS *in winter-time ?*

A. The *breath* and insensible *perspiration* of the sleeper (coming in contact with the ice-cold window) are *frozen* by the cold glass, and form those beautiful appearances seen in our bed-rooms on a winter's morning.

Q. *Why is the* GLASS *of a window colder, than the* WALLS *of a room?*

A. Because glass is so *excellent a radiator*, that it parts with its heat very *rapidly*.

Q. *Why is a* TUMBLER *of cold* WATER *made quite* DULL *with mist, when brought into a room* FULL *of* PEOPLE?

A. Because the *hot vapour* of the room (coming in contact with the cold tumbler) is *condensed* upon it; and changes its invisible and gaseous form, into that of a *thick mist*.

Q. *Why is a* GLASS *made quite* DULL, *by laying a* HOT HAND *upon it?*

A. Because the insensible *perspiration* of the hot hand is *condensed* upon the cold glass, and made perceptible.

Q. *Why are* WINE-GLASSES *made quite* DULL, *when they are brought into a room* FULL *of* COMPANY?

A. Because the *hot vapour* of the room (coming in contact with the cold wine-glasses) is condensed upon them, and covers them with vapour like dew.

Q. *Why does this misty appearance* GO OFF, *after a little time?*

A. Because the glass becomes of the same *temperature*, as the *air* of the room; and will no longer *chill* the *vapour* which touches it, and *condense* it into *mist*.

Q. *Why is a* WINE GLASS *(which has been brought out of a* CELLAR *into the* AIR) *covered with a thick* MIST *in summer-time?*

A. Because the vapour of the hot air is *condensed* by the cold glass, and covers it as a thick mist.

Q. *Why does* BREATHING *on a* GLASS *make it quite* DULL?

A. Because the hot breath is *condensed* by the cold glass; and, therefore, covers it with a thick mist.

Q. *Why do* WALLS *stand thick with* WET *in a sudden* THAW?

A. Because the walls (being thick) cannot *change* their *temperature* so fast as the air; in consequence of which, they *retain* their *cold* after the thaw has set in.

Q. *How does* "RETAINING *their* COLD" *account for their being so* WET?

A. As the vapour of the warm air touches the *cold wall*, it is *chilled* and

condensed into *water,* which either *sticks* to the wall, or trickles down in little streams.

Q. *Why does a thick* WELL-BUILT HOUSE *contract more* DAMP *of this kind, than an* ORDINARY *one?*

A. Because the walls are much thicker; and (if the frost has penetrated far into the *bricks)* they will be some time before they are reduced to the same *temperature* as the *air.*

Q. *Why are* BALUSTERS *&c.* DAMP *after a* THAW?

A. Because they are made of some very close-grained, varnished wood, which cannot *change* its *temperature* so *fast* as the air.

Balusters—corruptly called banisters.

Q. *How does* THIS *account for the* BALUSTERS *being* DAMP?

A. The vapour of the warm air (coming in *contact* with the *cold balusters)* is *chilled,* and condensed into *water* upon it.

Q. *Why is our* BREATH VISIBLE *in* WINTER, *and* NOT *in* SUMMER?

A. Because in *winter*, the coldness of the air condenses our breath into *visible vapour;* but in *summer*, the air is *not cold enough* to do so.

Q. *Why are our* HAIR, *and the* BRIM *of our* HAT, *often covered with little drops of pearly* DEW *in winter-time?*

A. Because our breath (as it comes in contact with our cold hair or hat) is condensed; and hangs there in little dew-drops.

Q. *Why does the* STEAM *of a* RAILWAY BOILER *often pour down, like fine rain, when the steam is "let off?"*

A. Because, in cold weather, the steam from the chimney is *condensed* by the *chill air*, and falls like fine rain.

Q. *Why is there* LESS DEW *when the* WIND *is* EASTERLY, *than when the wind is* WESTERLY?

A. *Easterly* winds cross the *continent of Europe*, and (as they pass over *land)* are dry and arid: But *westerly* winds cross the *Atlantic Ocean;* and (as they pass over *water)* are *moist* and *full of vapour.*

Q. *How does the* DRYNESS *of an easterly wind* PREVENT DEW-FALLS?

A. As the easterly winds are dry, they imbibe the moisture of the air; in consequence of which, there is *very little* left to be condensed into *dew.*

Q. *How does the* MOISTNESS *of a western wind* PROMOTE *dew-falls?*

A. As the westerly winds are *saturated* with *vapour,* they require a very little *reduction of heat* to cause a *copious deposition of dew.*

Q. *When is* DEW *most* COPIOUSLY *distilled?*

A. After a hot day in summer or autumn, especially if the *wind* be in the west.

Q. *Why is* DEW *distilled most* COPIOUSLY *after a* HOT *day?*

A. Because the surface of the hot earth *radiates* heat very freely at sunset; and (being made much *colder* than the *air) chills* the *passing vapour,* and condenses it into dew.

Q. *Does not* AIR *radiate heat, as well as the* EARTH *and its various plants?*

A. No. The air never *radiates heat;* nor is the air made *hot* by the *rays* of the *sun.*

Q. *How is the* AIR *made* HOT *or* COLD?

A. By convection of *hot* or *cold* currents.

Q. *What is meant by* "CONVECTION *of hot or cold currents?*"

A. The air which has been heated by the surface of the earth ascends, warming the air through which it passes. Other air (being warmed in a similar way) also *ascends*, carrying *heat;* till all the air is made hot.

Q. *Is the* AIR *made* COLD *in a similar way?*

A. Yes. The air resting on the earth is made *cold* by *contact:* this cold air makes the *air above* it *cold;* and cold currents (or winds) *shake* the *whole together*, till all becomes of one temperature.

Q. *Why is* MEAT *very subject to* TAINT *on a* MOON-LIGHT *night?*

A. In a bright moon-light night, *meat radiates heat* very freely; and is soon covered with *dew*, which produces rapid *decomposition*.

Q. *How do* MOON-LIGHT *nights conduce to the rapid* GROWTH *of* PLANTS?

A. In bright moon-light nights, (as

rapid *radiation* is carried on), *dew* is very plentifully *deposited* on young plants, which conduces much to their growth and vigour.

Q. *Why is evening* DEW INJURIOUS *to* HEALTH?

A. Because the condensed vapours are always laden with *noxious exhalations* from the *earth:* this is especially the case in *marshy* countries.

Q. *Is* HONEY-DEW *a similar thing to* DEW?

A. No. Honey-dew is a sweet liquid, shed by a very small *insect* (called the áphis), and deposited in autumn on the under surface of favourite leaves.

Q. *Does* HONEY-DEW INJURE *leaves, or do them good?*

A. It injures them very much, by filling the *pores* with a thick clammy liquid; in consequence of which, the leaf can neither *transpire,* nor *absorb* its needful food.

Q. *What* EFFECT *has honey-dew upon the* APPEARANCE *of a leaf?*

A. After a little time, the leaf (being *smothered* and *starved)* begins to turn a *dingy yellow.*

Q. *Are not* ANTS *very* FOND *of* HONEY-DEW?

A, Yes; and crawl up the loftiest trees, in order to obtain it

Q. *What is the cause of* MIST *(or earth-fog)?*

A. If the *night* has been very *calm*, the radiation of heat from the earth has been very abundant; in consequence of which, the *air* (resting on the earth) has been *chilled*, and its vapour condensed into a thick mist.

Q. *Why does not the* MIST *become* DEW?

A. Because the chill of the air is so *rapid*, that vapour is condensed *faster* than it can be *deposited*; and (covering the earth in a mist) prevents any further *radiation of heat* from the earth.

Q. *When the earth can no longer* RADIATE *heat upwards, does it continue to* CONDENSE *the vapour of the air?*

A. No; the air (in contact with the earth) becomes about equal in *temperature* with the surface of the earth itself; for which reason, the mist is not *condensed* into *dew*, but remains *floating* above the *earth* as a thick cloud.

Q. *How is it, that this* MIST *seems to* RISE HIGHER *and* HIGHER, *and yet remains quite as dense below as at first?*

A. The air resting on the *earth* is first chilled, and *chills* the air resting on *it*; the air which touches this *new layer* of mist being *also* condensed, layer is added to layer: And thus the mist seems to be *rising*, when (in fact) it is only *deepening*.

Q. *Why does* MIST *and* DEW VANISH, *as the* SUN *rises?*

A. Because the air becomes *warmer* at sun-rise, and *absorbs* the vapour.

Q. *Why is a* DEW-DROP ROUND?

A. Because every part of the drop is *equally balanced*; and, therefore, there is no cause why *one part* of the drop should be further from the centre, than *another*.

Q. *Why is the* DEW-DROP *(on a broad leaf) sometimes* FLATTENED?

A. Because two or more drops of dew *roll together*, and make one large *spheroid* (or flattened drop).

Q. *Why will* DEW-DROPS ROLL ABOUT CABBAGE-PLANTS, POPPIES, *&c. without wetting the surface?*

A. The leaves of cabbages and pop-

pies are covered with a very *fine waxen powder*, over which the dew-drop rolls (as a drop of rain over dust), without wetting the surface.

Q. *Why does not the drop of* RAIN WET *the* DUST *over which it rolls?*

A. Because dust has no *affinity* for water; and, therefore, repels it.

Q. *Why does not the* DEW-DROP WET *the* POWDER *of the* CABBAGE-*plant?*

A. Because the fine powder, which covers the cabbage-leaves, has no *affinity* for water; and, therefore, repels it.

Q. *Why will* DEW-DROPS ROLL *over a* ROSE, *&c. without wetting the petals?*

A. Because the leaves of a rose contain an *essential oil,* which has no *affinity* for water; and, therefore, repels it.

Q. *Why can* SWANS *and* DUCKS *dive under water* WITHOUT *being* WETTED?

A. Because their feathers are covered with an *oily secretion,* which has no *affinity* for water, and, therefore, repels it.

Q. *What is the cause of* MIST?

A. Currents of air from the *water,* mixing with colder *land* currents, are condensed (by contact) into *mist.*

Q. *Why are the currents of air from the* LAND, COLDER *than those blowing over* WATER ?

A. Because the earth radiates heat *very freely* after sun-set; and (being greatly cooled down) cools the *air* also, which comes in contact with it

For other questions respecting land and sea breezes, see Chapter XXII.

Q. *Why is not the* AIR, *which passes over* WATER, *so* COOL *as that, which passes over* LAND ?

A. Because *water* does not cool down at *sun-set*, so fast as *land* does; and, therefore, the air in contact with it is *warmer*.

Q. *Why does not* WATER *cool down so fast as* LAND ?

A. 1st—Because the *surface* of water is perpetually *changing;* and as fast as *one* surface is made cold, *another* is presented: and

2ndly—The moment water is made cold *it sinks*, and *warmer* portions of water *rise* to occupy its place: therefore, before the *surface of water is cooled*, the *whole volume* must be made cold; which is not the case with land.

Q. *What is the cause of a "pea-soup"* LONDON FOG?

A. These fogs (which occur generally in the winter time) are occasioned thus:—Some current of air (being suddenly cooled) *descends* into the *warm streets*, forcing back the smoke in a *mass* towards the earth.

Q. *Why are there not* ALWAYS FOGS, *every night?*

A. Because the air will always hold in solution a certain quantity of vapour, (which varies according to its temperature): and when the air is not *saturated*, it may be cooled without parting with its vapour.

Q. *Why are there* EVER FOGS *at night?*

A. If the air is saturated with *vapour* during the day, as soon as its capacity for holding vapour is lessened by the *cold night*, it deposits some of the superabundant moisture in the form of dew or fog.

Q. *Why is there very* OFTEN *a fog over* MARSHES *and* RIVERS, *at night-time?*

A. Because the air of marshes is

almost always near *saturation;* and, therefore, the least depression of *temperature,* will compel it to relinquish some part of its moisture in the form of dew or fog.

Q. *What is the* DIFFERENCE *between* DEW *and* RAIN?

A. In *dew,* the condensation is made near the *earth's surface.*

In *rain,* the drops fall from a considerable height.

Q. *What is the* CAUSE *of both dew and rain?*

A. COLD *condensing* the vapour of the *air,* when it is near the point of *saturation.*

Q. *Why do* MIST *and* FOG VANISH *at sunrise?*

A. Because the condensed particles are again *changed* into *invisible* vapour by the heat of the sun.

Q. *What is the difference between a* MIST *and a* FOG?

A. MIST is generally applied to *vapours* condensed on *marshes, rivers,* and *lakes.*

FOG is generally applied to *vapours*

condensed on *land;* especially if those vapours are laden with smoke.

Q. *What is the reason why condensed vapour sometimes forms into* CLOUDS, *and sometimes into* FOG?

A. If the surface of the EARTH be hotter than the *air,* the vapour of the earth (being *chilled* by the *cold air)* becomes FOG: But if the AIR be hotter than the *earth,* the vapour *rises through the air,* and becomes CLOUD.

Q. *If cold air produces* FOG, *why is it not foggy on a* FROSTY MORNING?

A. 1st—Because *less vapour* is formed on a *frosty day:* and

2ndly—The vapour is *frozen* upon the *ground,* before it can rise from the earth; and becomes HOAR-FROST.

Q. *Why are* FOGS *more general in* AUTUMN, *than in spring?*

A. 1st—Because the air in spring is generally much *drier,* than it is in autumn; in consequence of which, it is not so near the point of *saturation:* and

2ndly—The *earth* in spring is not so *hot,* as it is in autumn; in consequence

of which, its vapour is not chilled into fog, as it issues into the air.

Q. *Why are* FOGS *more common in* VALLEYS, *than on* HILLS?

A. 1st—Because valleys contain more *moisture* than *hills:* and

2ndly—They are *not exposed* to so much *wind,* which dissipates the vapour.

Q. *How does* WIND *dissipate* FOGS?

A. Either by *blowing* them away; or else by *dissolving* them into *vapour* again.

Q. *What is* HOAR-FROST?

A. There are two sorts of hoar-frost: 1.—FROZEN DEW: and 2.—FROZEN FOG.

Q. *What is the cause of the* GROUND *hoar-*FROST, *or frozen* DEW?

A Very *rapid radiation* of heat from the earth; in consequence of which, the *surface* is so *cooled down*, that it *freezes the dew* condensed upon it.

Q. *Why is* HOAR-FROST *seen only after a very* CLEAR NIGHT?

A. Because the earth will not have thrown off heat enough by radiation, to *freeze* the vapour condensed upon its

surface, unless the night has been very clear indeed.

Q. *Why does* HOAR-FROST *very often* COVER *the* GROUND *and* TREES, *when the water of rivers is not frozen.*

A. Because it is not the effect of cold in the *air,* but cold on the surface of the *earth* (produced by excessive radiation), which *freezes the dew* condensed upon it.

Q. *Why is the* HOAR-FROST *upon* GRASS *and* VEGETABLES *much thicker, than that upon lofty* TREES?

A. Because the air (resting on the *surface* of the ground) is much colder after sun-set, than the *air higher up;* in consequence of which, more *vapour* is *condensed* and *frozen* there.

Q. *Why is the* AIR *(resting on the surface of the* EARTH) *colder, than that in the* HIGHER *regions?*

A. Because the *earth* radiates more heat, than the *leaves* of lofty trees; and, therefore, *condenses* and *freezes* the vapour of the air more *rapidly.*

Q. *Why are* EVERGREENS *often* FROST-BITTEN, *when lofty trees are* NOT?

A. Evergreens do not rise far above

the surface of the earth; and (as the air *contiguous* to the earth is made *colder* by radiation, than that in the *higher* regions) therefore, the *low evergreen* is often *frost-bitten*, when the lofty tree is uninjured.

Q. *Why is there little or* NO HOAR-FROST *under* SHRUBS *and shadowy* TREES?

A. 1st—Because the leafy top *arrests* the process of radiation from the earth: and

2ndly—Shrubs and trees radiate a *little heat* towards the earth; and, therefore, the *ground beneath* is never *cold enough*, to *congeal* the little dew which rests upon it.

Q. *What is the cause of that* HOAR-FROST, *which arises from* FROZEN FOG?

A. The thick fog, which invested the earth during the night, (being condensed by the *cold frost* of early morning) is *congealed* upon *every object* with which it comes in contact.

CHAPTER XVII.

5.—CONVECTION.

Q. *What is meant by the* CONVECTION *of* HEAT?

A. Heat communicated by being *carried* to another thing or place; as the hot water resting on the *bottom* of a kettle, carries heat to the water through which it ascends. (*see p.* 252).

Q. *Are* LIQUIDS *good* CONDUCTORS *of heat?*

A. No; liquids are bad *conductors;* and are, therefore, made hot by *convection.*

Q. *Why are* LIQUIDS BAD CONDUCTORS *of heat?*

A. Because heat *converts a liquid* into *steam;* and flies off with the vapour, instead of being *conducted through* the liquid.

Q. *Explain how* WATER *is made* HOT?

A. The water *nearest the fire* is *first* heated, and (being heated) *rises* to the *top;* other cold water succeeding is *also* heated, and rises in turn; and this

interchange keeps going on, till *all the water boils.*

Q. *Why is* WATER *in such continual* FERMENT, *when it is* BOILING?

A. This commotion is mainly produced by the *ascending* and *descending currents* of hot and cold water.

The escape of *steam* from the water contributes also to increase this agitation.

Q. *How do these two currents* PASS *each other?*

A. The *hot ascending current* generally passes close by the metal sides of the kettle; while the *cold descending current* passes down the centre.

For other questions upon the subject of boiling water, see from page 115 to 122.

Q. *Why is* HEAT *applied to the* BOTTOM, *and not to the top of a* KETTLE?

A. Because the heated water always *ascends* to the *surface*, heating the water through which it passes: if, therefore, heat were applied to the *top* of a vessel, the water *below the surface* would never be *heated.*

Q. *As the lower part of a* GRATE *is made* RED-HOT *by the fire* ABOVE, *why would not the* WATER *boil, if fire were applied to the* TOP?

A. The *iron* of a grate is an excellent *conductor;* if, therefore, *one* part be heated, the heat is conducted to *every* other part: but *water* is a very *bad conductor,* and will not diffuse heat in a similar way.

Q. *How do you know that* WATER *is a* BAD CONDUCTOR *of heat?*

A. When a blacksmith immerses his red-hot iron in a tank of water, the water which surrounds the red-hot iron is made *boiling hot,* but the water *below* the surface remains quite cold.

Q. *If you wish to* COOL LIQUIDS, *where should the cold be applied?*

A. To the *top* of the *liquid;* because the *cold* portion will always *descend,* and allow the warmer parts to come in contact with the cooling substance.

Q. *Does* BOILING *water get hotter by being* KEPT *on the* FIRE?

A. No; not if the steam be suffered to escape.

Q. WHY *does not boiling water get* HOTTER, *if the steam be suffered to* ESCAPE?

A. Because the *water* is converted

into *steam* as fast as it boils; and the steam *carries away* the additional heat.

Q. *Is* STEAM *visible or* INVISIBLE?

A. Steam is *invisible;* but when it comes in contact with the air (being *condensed* into small drops) it instantly becomes visible.

Q. *How do you know, that* STEAM *is* INVISIBLE?

A. If you look at the spout of a boiling kettle, you will find that the steam (which issues from the spout) is always invisible for about *half an inch;* after which, *it becomes visible.*

Q. WHY *is the steam* INVISIBLE *for only* HALF AN INCH, *and not either all* INVISIBLE *or all* VISIBLE?

A. The air is not able to condense the steam as it first issues from the spout; but when it *spreads* and comes in contact with a larger volume of air, the *invisible steam* is readily condensed into *visible drops.*

Q. *Why do* STEAM-ENGINES *sometimes* BURST?

A. Steam is very *elastic;* and this elasticity increases in a greater propor-

tion, than the heat which produces it; unless, therefore, some *vent* be freely allowed, the steam will burst the vessel which confined it.

Q. *Is* AIR *a good* CONDUCTOR?

A. No; *air* is a very *bad conductor;* and is heated (like water) by *convection.*

Q. *How is a* ROOM WARMED *by a* STOVE?

A. The air *nearest* the fire is made hot *first,* and rises; as *cold air descends,* it is heated, and *ascends* in like manner; and this goes on, till *all* the air of the room is *warmed.* *(see p. 54.)*

Q. *Why are* FIRES *placed on the* FLOOR *of a room, and not towards the* CEILING?

A. As heated air always *ascends,* if the fire were not *near the floor,* the air of the *lower* part of the room would never be heated by the fire at all.

Q. *If you take a* POKER *out of the fire, and hold the* HOT END DOWNWARDS, *why is the* HANDLE *so intensely* HOT?

A. Because the hot end of the poker *heats the air* around it, and this hot air (in its ascent) *scorches* the *poker,* and the *hand* which holds it.

Q. *How should a* RED-HOT POKER *be carried, so as not to* BURN *our fingers?*

A. With the hot end *upwards;* for then the air (heated by the poker) would not pass over our hand and scorch it.

PART II.

AIR.

CHAPTER XVIII.

Q. *Of what is atmospheric* AIR *composed?*

A. Principally of two gases, *oxygen* and *nitrogen;* mixed together in the following proportion: viz. 1 part of oxygen, to 4 parts of nitrogen.

Q. *What do you mean by a* GAS?

A. A body whose particles are severed from each other *so far,* that they can move about *freely* among each other.

Q. *Why is* GAS INVISIBLE?

A. Because its particles are *too small* to be visible *separately;* and too far *asunder* to be seen *collectively;* as, therefore, we see *between* these minute particles, the gas is *transparent.*

Q. *What is the difference between a* GAS *and a* LIQUID?

A. Gases are *elastic,* but liquids are *not.*

Q. *Illustrate what is meant by "the* ELASTICITY *of* GAS."

A. If from a vessel full of gas *half* were taken out—the *other* half would immediately spread itself out, and fill the same space as was occupied by the *whole.*

Q. *How do you know that a* LIQUID *is* NOT ELASTIC?

A. If from a gallon of water you take *half,* the remaining 4 pints will take up only *half* the room, that the whole gallon previously did: A *liquid,* therefore, is not elastic, like *gas.*

Q. *What are the uses of the* OXYGEN *of the air?*

A. It *supports* combustion, and *sustains* life.

Q. *What is meant, when it is said, that the* OXYGEN *of the air* "SUPPORTS COMBUSTION?"

A. It means this; that it is the *oxygen* of the air, which makes *fuel burn.*

Q. *How does the* OXYGEN *of the air make* FUEL BURN?

A. The fuel is decomposed (by heat) into *hydrogen* and *carbon;* and these elements combining with the *oxygen* of the air, produce combustion.

Q. *What* GAS *is produced by the combination of carbon and oxygen?*

A. CARBONIC ACID GAS. (*see p.* 39).

Q. *What becomes of the* HYDROGEN *of the* FUEL?

A. The *hydrogen* of the fuel combines with the *oxygen* of the air, and forms WATERY VAPOUR; but the combination is attended by the production of *flame,* owing to the very inflammable nature of hydrogen gas.

Q. *What becomes of the* NITROGEN *of the air, amidst all these changes and combinations?*

A. The nitrogen escapes *unchanged,* to be again mixed with *oxygen,* and converted into common AIR.

Q. *What is meant, when it is said, that* OXYGEN "SUSTAINS LIFE?"

A. It means this: if a person *could not inhale oxygen,* he would *die.*

Q. *What* GOOD *does this inspiration of* OXYGEN *do?*

A. 1st—It gives *vitality* to the *blood:* and

2ndly—It is the *cause* of *animal heat.*

Q. *How is* FOOD *converted into* BLOOD?

A. After it is swallowed, it is dissolved in the stomach into a *grey pulp,* called CHYME; it then passes into the intestines, and is converted by the "bile" into a *milky substance,* called CHYLE.

Chyme *pronounce* kyme—chyle *pronounce* kyle—*both as one syllable.*

Q. *What* BECOMES *of the milky substance, called* CHYLE?

A. It is absorbed by the vessels called "*lac'teals,*" and poured into the veins on the *left side of the neck.*

Q. *What becomes of the chyle* AFTER *it is* POURED *into the* VEINS?

A. It then *mingles* with the *blood,* into which it is *converted.*

Q. How *does the* OXYGEN *we inhale* MINGLE *with the* BLOOD?

A. The oxygen of the air mingles with the blood *in the lungs,* and converts it into a *bright red colour.*

Q. *What colour is the blood* BEFORE *it is oxydized in the lungs?*

A. *A dark purple.* The oxygen turns it to a *bright red.*

Oxydized, i.e. impregnated with oxygen.

Q. *Why are* PERSONS *so* PALE, *who live in* CLOSE ROOMS *and* CITIES?

A. Because the blood derives its redness from the *oxygen* of the air inhaled; but, as the air in close rooms and cities is not *fresh*, it is *deficient in oxygen*, and cannot turn the blood to a beautiful bright red.

Q. *Why are* PERSONS, *who live in the* OPEN AIR *and in the country, of a* RUDDY *complexion?*

A. As the blood derives its bright red colour from the *oxygen* of the air inhaled, therefore, country-people (who inhale *fresh air)* are more ruddy than citizens.

Q. *Why is not the air in* CITIES *so* FRESH, *as that in the* COUNTRY?

A. Because it is impregnated with the *breath* of its numerous *inhabitants*, the *odour* of its *sewers*, the *smoke* of its *fires*, and many other impurities.

Q. *How does* OXYGEN *convert the colour of blood into a bright* RED?

A. The *colouring* matter of the blood is formed by very minute *globules* floating in it; the oxygen (uniting with the *coats of these globules)* makes them *milky*,—and the dark colouring matter of the blood (seen through this *milky coat)* appears of a *bright red.*

Exp: If you put some dark *venous* blood into a *milky* glass, and hold it up towards the light, it will appear of a *bright florid* colour, like *arterial* blood.

Q. *How does the* COMBINATION *of* OXYGEN *with the* BLOOD *produce animal* HEAT?

A. The principal element of the blood is *carbon*, which (combining with the oxygen of the air inhaled) produces *carbonic acid gas,* in the same way as burning fuel. (*see p.* 39).

Q. *What becomes of the* NITROGEN *of the air, after the oxygen enters the blood?*

A. The nitrogen is *exhaled* unchanged, to be again mixed with *oxygen*, and converted into common AIR.

Q. *Why does the vitiated air (after the oxygen has been absorbed)* COME OUT *of the* MOUTH, *and not sink into the stomach?*

A. Because a mechanical provision is made in the upper part of the windpipe and gullet for this purpose.

N.B. The lungs are a *hollow spongy mass*, capable of confining air, and of being *dilated* by it. They are so situated in the thorax (or chest), that the air *must* enter into them, whenever the cavities of the thorax are enlarged. The process of breathing is performed thus: When we INHALE, the thorax (or chest) is expanded; in consequence of which, a *vacuum is formed round the lungs*, and heavy external air instantly enters (through the mouth and throat) to *supply* this vacuum.

When we EXHALE, the thorax *contracts* again; in consequence of which, it can no longer contain the *same quantity* of air as it did before, and some of it is necessarily *expelled*. When this expulsion of air takes place, the lungs and *muscular fibres* of the wind pipe and gullet *contract*, in order to assist the process.

Q. *If (both in combustion and respiration) the* OXYGEN *of the air is* CONSUMED, *and the* NITROGEN REJECTED—*Why are not the* PROPORTIONS *of the* AIR DESTROYED?

A. Because the *under surface of vegetable leaves* (during the day) gives out *oxygen*, and thus restores to the air the very element of which it has been deprived.

Q. *Whence do leaves* OBTAIN *the oxygen, which they exhale?*

A. From the *carbonic acid*, absorbed by the *roots* from the soil, and carried to the leaves by the rising *sap*.

N.B. Carbonic acid (it must be remembered) is a compound of carbon and oxygen.

Q. How *do plants contrive to absorb carbonic acid from the soil?*

A. Being dissolved in water it rises (by capillary attraction) through the small fibrous roots.

Q. *Whence does the* SOIL *obtain carbonic acid?*

A. 1st—From the air; from which it is driven by falling showers:

2ndly—From the decomposition of vegetable and animal matters, which always produces this gas in abundance: and

3rdly—All lime-stone, chalk, and calcareous stones, contain vast quantities of carbonic acid in a *solid* state.

Calcareous i. e. of a limy nature.

Q. *If leaves throw off the* OXYGEN *of the carbonic acid, what becomes of the carbon?*

A. It is retained, to give *firmness* and *solidity* to the plant itself.

Q. *Show how God has made* ANIMAL *life dependent on that of* VEGETABLES?

A. *Animals* require *oxygen* to keep them alive, and *draw it from the air* by inspiration: The under surface of *leaves gives out oxygen;* and thus supplies the

air with the *very gas* required for the use of animals.

Q. *Show how God has made* VEGETABLE *life dependent on that of animals?*

A. Plants require *carbonic acid,* which is their *principal food;* and all animals exhale the same gas from their lungs. Thus *plants* supply animals with *oxygen,* and *animals* supply plants with *carbonic acid.*

Q. *How is* AIR HEATED?

A. By "convective currents."

Q. *Explain what are meant by* "CONVECTIVE CURRENTS."

A. When a portion of air is heated, it *rises upward in a current,* carrying the heat with it: other *colder air succeeds,* and (being *heated* in a similar way) *ascends also:* These are called "convective currents."

("Convective currents;" so called from the Latin words, cum vectus (*carried with*); because the *heat* is "carried with" the current.)

Q. *Is* AIR HEATED *by the* RAYS *of the* SUN?

A. No; air is *not heated* (in any sensible degree) *by the action of the sun's rays* passing through it.

Q. *Why then is the* AIR HOTTER *on a* SUNNY DAY, *than on a* CLOUDY *one?*

A. On a fine day, the sun *heats the surface* of the *earth*, and the air (resting on the earth) is *heated by contact:* as soon as it is heated, *it ascends;* and *other* air succeeding, is *heated in a similar way,* till all is heated by convection.

Q. *If* AIR *be a* BAD CONDUCTOR, *why does hot* IRON *get* COLD, *by being* EXPOSED *to the* AIR?

A. A piece of hot iron (exposed to the air), is made cold—1st—By "convection;" and 2ndly—By "radiation."

Q. *How is hot iron (exposed to the air) made cold by* CONVECTION?

A. The air resting on the hot iron (being intensely heated), rapidly ascends with the heat it has absorbed; *colder* air succeeding, *absorbs more heat,* and ascends also; and this process is repeated, till the hot iron *is cooled completely down.*

Q. *How is hot iron cooled by* RADIATION?

A. While the heat of the iron is being carried off by "convection," it *throws off heat* (on all sides) *by radiation* also.

Q. *What is meant by* RADIATION?

A. Heat emitted (in all directions) from any surface, by *innumerable rays.*

Q *Why is* BROTH COOLED *by being left exposed to the* AIR?

A. Hot broth throws off *some* heat by *radiation;* but it is *mainly* cooled down by *convection.*

Q *How is hot* BROTH *cooled down by* CONVECTION?

A. The air *resting* on the *hot broth* (being heated) *ascends; colder* air succeeding, *absorbs more heat,* and *ascends also;* and this process is repeated, till the broth is *made cool.*

The particles on the surface of the broth *sink* as they are cooled down, and *warmer* particles rise to the surface; which greatly assists the cooling process.

Q. *Why is hot* TEA *and* BROTH COOLED *faster, for being* STIRRED *about?*

A. 1st—Because the agitation assists in bringing its *hottest particles* to the *surface:*

2ndly—The action of stirring *agitates the air,* and brings it more *quickly* to the broth or tea: and

3rdly—As the hottest particles are

more rapidly brought into contact with the air, therefore *convection is more rapid.*

Blowing tea or broth cools it also. (*see p.* 186).

Q. *If a shutter be closed in the day-time, the stream of light (piercing through the crevice) seems in* CONSTANT AGITATION. WHY *is this?*

A. Because little *motes* and *particles of dust* (thrown into agitation by the violence of the *convective currents*) are made *visible* by the strong beam of light, thrown into the room through the crevice of the shutter.

Q. *Why is the* GALLERY *of a* CHURCH *or theatre* HOTTER, *than the* AISLE *or pit?*

A. Because the hot air ascends from the *bottom* to the *top of the building;* and cold air (from the doors and windows) flows to the *bottom,* to supply its place.

Q. *Why do persons, who ascend in balloons, feel intense pain in their eyes and ears?*

A. Because the air of the upper regions is *more rarefied,* than the air on the earth; and the air inside their bodies (seeking to become of the same rarity) *bursts through their eyes and ears,* producing an intense pain.

Q. *Why is it often* PAINFUL, *and difficult to* BREATHE, *on a* MOUNTAIN *top?*

A. Because the pressure of air on the mountain-top is *not so great, as on the plain;* and the air inside our bodies (seeking to become of the same rarity) *bursts through the pores of the body*, and produces great pain.

Q. *Why do we feel* OPPRESSED *just* PREVIOUS *to a storm?*

A. Because the air is greatly *rarefied by heat and vapour;* and the air inside us (seeking to become of the same rarity) produces an oppressive and suffocating feeling.

Q. *Why do* DIVERS *suffer great pain in their eyes and ears under water?*

A. Because the air at the bottom of the sea *is more dense,* than the air on the *surface;* and, (till the air inside the diver's body is settled into the same density,) he feels oppressed with pain, especially in the ears.

Q. *Why is this* PAIN *felt especially about the* EARS *of a* DIVER?

A. The ear is fitted with a small

membrane, called *the drum* (or tympanum), through which the dense air bursts; and the rupture very often *produces incurable deafness.*

Q. *Why do our* CORNS *ache just previous to* RAIN?

A. Because *our feet swell* from the sudden depression in the density of air; and the hard corn *(not being elastic)* is painfully stretched and pressed.

(Some of this pain is due to electricity.)

Q. *How do you know that the density of the air is lowered, previous to a storm?*

A. Because the *mercury* of a barometer rapidly *falls.*

Q. *Why do* CELLARS *feel* WARM *in* WINTER?

A. Because the external air has not free access into them; in consequence of which, they remain almost at an *even temperature,*—which (in winter time) is about 10 degrees *warmer,* than the external air.

Q. *Why do* CELLARS *feel* COLD *in* SUMMER *time?*

A. Because the external air has not free access into them; in consequence of

which, they remain almost at an *even temperature*,—which (in summer time) is about 10 degrees *colder*, than the external air.

Q. *Why does* AIR *rust* IRON?

A. Because the *oxygen of the air* combines with the *surface* of the *iron*, and produces *oxide of iron*; which is generally called "rust."

Q. *Why does hot iron* SCALE *and* PEEL *off, when struck with a* HAMMER?

A. Because the *oxygen of the air* very readily unites with the surface of the *hot iron*, and forms a metallic oxide (or rust), which scales off, when struck with a hammer.

Q. *Does iron* RUST *in* DRY *air?*

A. No; iron undergoes no change in dry air.

Q. *Why do* STOVES *and* FIRE-IRONS *become* RUSTY *in rooms, which are not* OCCUPIED?

A. Because the air is damp; and moist air *oxidizes* iron and steel.

Oxidizes, i. e. rusts.

Q. *In what part of the year is it most difficult to keep* STOVES *and* FIRE-IRONS BRIGHT?

A. In *autumn* and *winter*.

Q. *Why is it more difficult to keep* STOVES *and* FIRE-IRONS *bright in* AUTUMN *and* WINTER, *than in spring and summer?*

A. Because the capacity of the air for holding water is constantly on the *decrease,* after the summer is over; in consequence of which, vapour is deposited on everything with which the air comes in contact.

Q. *Why does* GREASING *iron prevent its becoming* RUSTY?

A. Because *grease* prevents the humidity of air from coming in contact with the *surface* of the *iron.*

Q. *Why do not* STOVES *rust, so frequently as* POKERS *and* TONGS?

A. Because stoves are generally *covered with plumbago,* or black lead.

Q. *What is plumbago, or black lead?*

A. A mixture of charcoal and iron.

PLUMBAGO. (strictly speaking), is a chemical union of *carbon* and *iron*, in the following proportions:—91 parts carbon, and 9 iron. But the BLACK LEAD sold in shops is a mixture of charcoal and iron filings.

N. B. A most excellent varnish to prevent rust is made of 1 pint of fat oil varnish, mixed with 5 pints of highly rectified spirits of turpentine, rubbed on the iron or steel with a piece of sponge. This varnish may be applied to bright stoves, and even mathematical instruments, without injuring their delicate polish.

Q. *Why does ornamental* STEEL *(of a purple or* LILAC *colour) rust more readily, than polished* WHITE *steel ?*

A. Because the lilac tinge is produced by *partial oxidation ;* and the process which forms rust, has, therefore, already commenced.

Q. *How can lilac* STEEL *be kept* FREE *from* RUST ?

A. By keeping it in a very *dry place ;* for then no additional oxygen will come in contact with it, to increase the amount of rust.

Q. *If* DRY AIR *contains* OXYGEN, *why does it* NOT RUST IRON, *as well as* MOIST *air ?*

A. Because it is the *water* in the air, which is decomposed by the contact with iron : For iron has a much stronger tendency to unite with the oxygen of *water,* than with the oxygen of dry *air.*

Q. *Do any* OTHER *metals (besides iron) combine rapidly with oxygen ?*

A. Yes ; copper, lead, mercury, and even silver to some extent.

Q. *Why does* COPPER TARNISH ?

A. The tarnish of copper is caused

by its *oxidation:* that is, the oxygen of the air combines with the surface of the copper, and (instead of *rusting it*), covers it with a *dark tarnish.*

Q. *Why does* LEAD *become of a* DARKER *hue, by being exposed to the air?*

A. Because the vapour of the air combines with the lead, and *oxidizes its surface;* but instead of becoming *rusty,* the surface assumes a *darker hue.*

Q. *Why does* LEAD *lose its* BRIGHTNESS, *and become* DULL, *by being exposed to the air?*

A. The *dullness* of the lead is caused by the presence of a *carbonate* of the oxide: When the oxide is formed, it attracts *carbonic acid* from the air, and (combining with it) produces a *carbonate,* which gives the *dull* tint to old lead.

Q. *Why is it difficult to keep* SILVER BRIGHT?

A. Because the vapour of the air oxidizes its surface, and *tarnishes* it.

Q *Why do silver* TEA-POTS *and* SPOONS *tarnish more quickly, than silver ore or bullion?*

A. Because alloy (of some *baser* metal) is used, to make them more *hard and lasting;* and this *alloy* oxidizes more quickly, than silver itself.

Q. *Why does* GERMAN *silver turn a dingy yellow in a few hours?*

A. Because German silver has a great affinity for oxygen; and shows its oxidation by a *sickly yellow tarnish,* instead of rust.

Q. *If quicksilver (or mercury) is tarnished, like copper and lead,—why does it preserve its* BRILLIANCY *in* BAROMETERS *and* THERMOMETERS?

A. Because *air* is excluded from it, and no moisture comes in contact with it, to *oxidize* (or *tarnish)* it.

Q. *Is* GOLD *affected by the atmosphere?*

A. Not readily: gold will never combine with oxygen of itself, (i. e. without aid).

Q. WHICH *of the* METALS *is capable of resisting oxidation altogether?*

A. Plat'inum; in consequence of which, the graduated arcs of delicate "instruments-for-observation" are made of plat'inum, instead of any *other* metal.

Q. *Why is* PLAT'INUM *used for the graduated arcs of delicate mathematical instruments, instead of any other metal?*

A. Because it will never oxidize; but retain its *bright surface* in all weathers, free from both *rust* and *tarnish.*

Q. *Before plat'inum was discovered, which of the metals was employed for the same purpose?*

A. Gold.

Platinum, (a white metal), so called from "plata," the Spanish word for *silver*. It was introduced from South America into England by Mr. Wood, (A. D. 1749).

Q. *For what other* SCIENTIFIC *purposes is* PLAT'INUM *now used?*

A. For crucibles in which *acids* are employed; and for galvanic batteries.

Q. *Why are* CRUCIBLES *(in which acids are employed) made of* PLAT'INUM?

A. Because the acid would act upon *other metals,* or upon *glass;* and prevent the experimenter's success.

Q. *Which of the* METALS *have the* GREATEST *affinity for* OXYGEN?

A. Those called *potas'sium* and *so'dium.*

Potas'sium and so'dium derive their names from potash and soda. Potas'sa is the oxide of potas'sium; and soda is the oxide of so'dium.

Q. *How is the affinity of potas'sium and so'dium for oxygen shewn?*

A. They *decompose water* immediately they are brought into contact with it.

Q. *What* EFFECT *has* POTAS'SIUM *on* WATER?

A. It catches *fire* the moment it is

thrown into water, and burns with a vivid flame,—which is still further increased by the combustion of *hydrogen*, separated from the water.

(N. B. Water is composed of oxygen and hydrogen; and potas'sium separates the two gases.)

Q. *What effect has* SO'DIUM *on* WATER?

A. It does not take *fire*, as potassium does; but undergoes very rapid *oxidation*.

Q. *Is the* FURR *of* KETTLES *an oxide?*

A. No; the furr (or deposit of boiling water) is a precipitate of *lime and mineral salt*, separated from the water by the process of boiling.

Q. *Is not this* FURR *of boiling water often* DANGEROUS?

A. Yes; especially in *tubular boilers*, such as those employed in railways.

Q. *Why is this* FURR *especially* TROUBLESOME *in* RAILWAY *engines?*

A. Because it is a *bad conductor of heat;* in consequence of which, it hinders the *evaporating effect* of the fire, and prevents the economy of fuel.

Q. *Why is this* FURR *especially* DANGEROUS *in* RAILWAY *engines?*

A. Because, when it is deposited in the boilers, they are likely to become *over-heated;* and then *explosion* will take place, from the sudden generation of highly elastic steam.

Q. *Why cannot* RAILWAY *engines be fed with* BRACKISH WATER?

A. Because *brackish* water contains *mineral salt;* which makes a much larger deposit of furr, than water which contains *only vegetable matters.*

CHAPTER XIX.

CARBONIC ACID GAS.

Q. *What is* CARBONIC ACID GAS?

A. A gas formed by the union of *carbon* and *oxygen:* It used to be called "FIXED AIR."

3 lbs. of carbon and 8 lbs. of oxygen will form 11 lbs. of carbonic acid.

Q. *Under what circumstances does* CARBON *most readily* UNITE *with* OXYGEN?

A. 1st—When its *temperature* is *raised:* Thus if carbon be *red hot,* oxygen will most readily unite with it: and

2ndly—When it forms part of the fluid *blood.*

Q. *Why do oxygen and carbon so readily unite in the* BLOOD?

A. Because the atoms of carbon are so *loosely attracted* by the *other* materials of the blood, that they unite very readily with the oxygen of the air inhaled.

Q. *Is carbonic acid* WHOLESOME?

A. No; it is *fatal to animal life;* and (whenever it is inhaled) acts like a narcotic poison,—producing drowsiness, which sometimes ends in death.

Q. *How can any one* KNOW, *if a place be infested with* CARBONIC ACID GAS?

A. If a pit or well contain carbonic acid, *a candle* (let down into it) will be *instantly extinguished.* The rule, therefore, is this—Where a *candle will burn, a man can live;* but *what will extinguish a candle,* will also *destroy life.*

Q. *Why does a* MINER *lower a* CANDLE *into a mine, before he descends?*

A. Because the *candle will be extinguished,* if the mine contains carbonic acid gas: but if the candle is *not extinguished,* the mine is *safe,* and the man may fearlessly descend.

Q. *Why does a* CROWDED ROOM *produce* HEAD-ACHE?

A. Because we breathe air *vitiated* by the crowd.

Q. *Why is the* AIR *of a room* VITIATED *by a* CROWD?

A. Because it is deprived of its due proportion of *oxygen,* and laden with *carbonic acid* and *nitrogen.*

Q. How *is the air of a room affected thus by a crowd?*

A. The *elements* of the air (inhaled by the breath) are *separated* in the *lungs;*—the *oxygen* is converted in the blood into *carbonic acid;* and the carbonic acid (together with the nitrogen) is then thrown off by the breath into the room.

Q. *Is* ALL *the* NITROGEN REJECTED *by the lungs?*

A. Yes; *all* the nitrogen of the air is always *expired.*

Q. *Why is a* CROWDED ROOM UNWHOLESOME?

A. Because the oxygen of the air is *absorbed* by the *lungs;* and carbonic acid gas (which is a noxious poison) is substituted for it.

Q. *Mention the historical circumstances, so well known in connexion with the* "BLACK HOLE *of* CALCUTTA."

A. In the reign of George II, the Raja (or Prince) of Bengal* marched suddenly to Calcutta, to drive the English from the country; as the attack was unexpected, the English were obliged to submit, and 146 persons were taken prisoners.

Q. *What became of these prisoners?*

A. They were driven into a place about 18 feet square, and 15 or 16 feet in height, with only two small grated windows. 123 of the prisoners died in one night; and (of the 23 who survived) the larger portion died of putrid fevers, after they were liberated.

* The Sur Raja, at Dowlat; a young man of violent passions, who had but just succeeded to the throne. A. D. 1756.

Q. *Why were* 123 *persons* SUFFOCATED *in a few hours, from confinement in this close hot* PRISON-*hole?*

A. Because the *oxygen* of the air was soon *consumed* by so many lungs, and its place supplied by *carbonic acid* exhaled by the hot breath.

Q. *Why did the captives in the* BLACK HOLE *die* SLEEPING?

A. 1st—Because the *absence of oxygen* quickly affects the vital functions, depresses the nervous energies, and produces a lassitude which ends in death: and

2ndly—The *carbonic acid gas* (being a narcotic poison) produces *drowsiness* and *death*, in those who inhale it.

Q. *Why are the* JUNGLES *of Java and Hindostan so* FATAL *to life?*

A. Because vast quantities of *carbonic acid* are thrown off by decaying *vegetables;* and (as the wind cannot penetrate the thick brushwood to blow it away) it *settles* there, and destroys animal life.

Q. *Why do persons in a crowded* CHURCH *feel* DROWSY?

A. 1st—Because the crowded congregation *inhale a large portion* of the *oxygen* of the air, which alone can sustain vitality and healthy action: and

2ndly—The air of the church is impregnated with carbonic acid gas, which (being a strong narcotic) produces drowsiness in those who inhale it.

Q. *Why do* PERSONS, *who are much in the* OPEN AIR, *enjoy the best* HEALTH?

A. Because the air they inhale is *much more pure.*

Q. *Why is* COUNTRY AIR *more* PURE, *than the air in* CITIES?

A. 1st—Because there are fewer inhabitants to vitiate the air:

2ndly—There are more trees to restore the equilibrium of the vitiated air: and

3rdly—The free circulation of air keeps it pure and wholesome (in the same way as running streams are pure and wholesome, while stagnant waters are the contrary).

Q. *Why does the* SCANTINESS *of a country* POPULATION *render the* COUNTRY AIR *more* PURE?

A. Because the fewer the inhabitants, the *less carbonic acid* will be *exhaled*; and thus country people inhale *pure oxygen*, instead of air impregnated with the narcotic poison, called carbonic acid gas.

Q. *Why do* TREES *and* FLOWERS *help to make country* AIR WHOLESOME?

A. 1st—Because trees and flowers *absorb the carbonic acid* generated by the lungs of animals, putrid substances, and other noxious exhalations: and

2ndly—Trees and flowers restore to the air the *oxygen*, which has been inhaled by man and other animals.

Q. *Why is the* AIR *of* CITIES LESS *wholesome, than* COUNTRY *air?*

A. 1st—Because there are more *inhabitants* to vitiate the air:

2ndly—The *sewers, drains, bins,* and *filth* of a *city*, very greatly vitiate the air:

3rdly—The streets and alleys prevent a free circulation: and

4thly—Besides all this, there are fewer trees to absorb the excess of carbonic acid gas, and restore the *equilibrium*.

Q. *Why are* PERSONS, *who live in* CLOSE ROOMS *and crowded* CITIES, *generally* SICKLY ?

A. Because the air they breathe is not pure, but is (in the 1st place) *defective in oxygen ;* and (in the 2nd) impregnated with *carbonic acid gas.*

Q. *Where does the* CARBONIC ACID *of close* ROOMS *and* CITIES COME *from ?*

A. From the lungs of the inhabitants, the sewers, drains, and other like places, in which organic substances are undergoing *decomposition.*

Q. *What* BECOMES *of the* CARBONIC ACID *of crowded cities ?*

A. Some of it is *absorbed by vegetables,* and the rest is *blown away* by the *wind,* and diffused through the whole volume of the air.

Q. *Does not this constant diffusion of carbonic acid affect the* PURITY *of the* WHOLE AIR ?

A. No ; because it is wafted by the wind from place to place, and *absorbed* in its passage by the *vegetable world.*

Q. *What is* CHOKE DAMP ?

A. *Carbonic acid gas* accumulated at the bottom of wells and pits, which renders them noxious, and often fatal to life.

Q. *Why is not this carbonic acid* TAKEN UP *by the* AIR, *and* DIFFUSED, *as it is in cities?*

A. Because (being *heavier than common air)* it cannot *rise from the well or pit;* and no wind can get to it, to blow it away.

Q. *Why are* PERSONS *sometimes* KILLED, *by leaning over* BEER VATS?

A. Vats (where beer has been made) contain a large quantity of *carbonic acid gas,* produced by the "vinous fermentation" of the beer; and when a man incautiously *leans over a beer vat,* and inhales the carbonic acid, he is immediately *killed* thereby.

Q. *Why are* PERSONS *often* KILLED, *who enter* BEER VATS *to clean them?*

A. Carbonic acid (being heavier than *atmospheric air)* often rests upon the *bottom of a vat:* when, therefore, a person enters the vat, and *stoops to clean the bottom,* he inhales the pernicious gas, which *kills* him.

Q. *Why are* PERSONS *sometimes* KILLED *by having a* CHARCOAL FIRE *in their bed-rooms?*

A. When charcoal is burned, the

carbon of the charcoal unites with the *oxygen of the air,* and forms *carbonic acid gas,* which is a narcotic poison.

Q. *If carbonic acid settles at the* BOTTOM *of a room, how can it injure a person* LYING *upon a* BED, *raised considerably above the floor?*

A. All gases *diffuse* themselves *through each other,* as a drop of *ink* would diffuse itself through a cup of water. If, therefore, a person slept for 6 or 8 hours in a room containing carbonic acid, quite enough of the narcotic will have spread itself by this time to produce death.

The *heat* of the fire assists this process of diffusion.

Q. *What are the chief* SOURCES *of* CARBONIC ACID?

A. 1.—The breath of animals. 2.—The decomposition of vegetable and animal matter. 3.—Lime-stone, chalk, and all calcareous stones, in which it exists in a *solid* form.

Q. *From which of these sources is* CARBONIC ACID *most likely to* ACCUMULATE *to a noxious extent?*

A. From the fermentation and putrefaction of decaying vegetable and animal matters.

Q. *How can this* ACCUMULATION *of* CARBONIC ACID *be* PREVENTED ?

A. By throwing *quick-lime* into places, where such fermentation and putrefaction are going on.

Q. *How will quick-*LIME PREVENT *the accumulation of* CARBONIC ACID ?

A. Quick-lime will *absorb* the carbonic acid; and produce a combination called "carbonate of lime."

Q. *Does not heavy* RAIN *prevent the* ACCUMULATION *of* CARBONIC ACID, *as well as quick-lime ?*

A. Yes; an abundant supply of *water* will prevent the accumulation of carbonic acid, by *dissolving* it.

Q. *What effect has* CARBONIC ACID *on the* WATER, *in which it is dissolved ?*

A. It renders it slightly *acid* to the taste.

Q. *Can the* CAPACITY *of water for dissolving carbonic acid be increased ?*

A. Yes. If water be condensed by *pressure,* it will dissolve *much more* carbonic acid, than it will otherwise.

Q. *To what practical* USES *has this capacity of water (for dissolving carbonic acid) been applied ?*

A. *Effervescing draughts* are made upon this principle.

Q. *Explain the cause of* EFFERVESCENCE *in these beverages.*

A. The carbonic acid of the beverage (being prevented by the cork from *escaping*) *condenses the liquid* by its pressure, and is *absorbed* by it: but when the cork or pressure is removed, (as the liquid can no longer retain the same quantity of carbonic acid,) some of it flies off in *bubbles* or *effervescence.*

Q. *Why does* AERATED WATER *effervesce, when the* CORK *is removed?*

A. While the bottle remains *corked,* the water (being condensed) *absorbs* the carbonic acid: but when the cork (or *pressure*) is *removed,* (as the liquid can no longer retain the same quantity of carbonic acid,) some of it flies off with *effervescence.*

Q. *Why does* SODA WATER *effervesce?*

A. Soda water contains 8 times its own bulk of carbonic acid gas, which makes its escape in *effervescence,* as soon as the *cork is removed.*

Q. *Why does* GINGER POP *fly about in froth, when the string of the cork is cut?*

A. All vinous fermentation produces carbonic acid gas. While the *cork is fast,* the water of the liquor *absorbs* the carbonic acid; but when the *pressure is removed,* the gas is given off in *effervescence.*

Q. *Why does* BOTTLED ALE *froth more, than* DRAUGHT *ale?*

A. Because the *pressure* is greater in a *bottle,* than in a tub which is perpetually tapped: and effervescence is always increased by *pressure.*

Q. *What produces the* FROTH *of* BOTTLED PORTER?

A. *Carbonic acid,* set free by its *vinous fermentation*: This gas is *absorbed* by the *liquor,* so long as the bottle is well *corked;* but is given off in froth, as soon as the pressure of the cork is removed.

Q. *What gives the pleasant* ACID *taste to soda water, ginger beer, champagne, and cider?*

A. The presence of *carbonic acid,* generated by fermentation; and liberated by effervescence, when the pressure of the cork is removed.

Q. *Why does fresh* SPRING WATER SPARKLE, *when poured from one vessel to another?*

A. Because fresh spring and pump water contain *carbonic acid;* and it is the presence of this gas, which makes the water *sparkle.*

Q. *What is the* FERMENTATION *of* BEER *and* WINE?

A. The escápe of carbonic acid, produced by the change of *sugar* into *al'cohol.*

Q. *What is* AL'COHOL?

A. The *spirit* of beer and wine, obtained by fermentation.

Q. *Of what* ELEMENTS *is* AL'COHOL *composed?*

A. Of carbon, oxygen, and hydrogen.

Of AL'COHOL, 4 parts are carbon; 2 oxygen; and 6 hydrogen.

Q. *What are the* ELEMENTS *of grape* SUGAR?

A. Carbon, oxygen, and hydrogen, all in equal proportions.

Q. *What* CHANGES *does* SUGAR *undergo by* FERMENTATION?

A. It is first decomposed; and then its elements re-unite in different propor-

tions; producing *al'cohol, carbonic acid,* and *water.*

Of SUGAR, one portion is alcohol; and another carbonic acid; as may be seen by the following table.

	Carb.	Oxy.	Hyd.
Every atom of unhydrous sugar contains	12	12	12
Two atoms of alcohol contain	8	4	12
Four atoms of carbonic acid contain	4	8	0
	12	12	12

Unhydrous sugar is sugar *dried* at 300°.

Q. *How does* SUGAR *form* AL'COHOL *by fermentation?*

A. *Two-thirds* of its carbon and *one-third* of its oxygen re-unite with the hydrogen, and generate *al'cohol.*

Q. *How does* SUGAR *form* CARBONIC ACID *by fermentation?*

A. The remaining *one-third* of its carbon and *two-thirds* of its oxygen re-unite, and generate *carbonic acid.*

Q. *What* BECOMES *of the* AL'COHOL, *which is thus generated by fermentation?*

A. It mixes with the *water,* and forms the *intoxicating* part of beer and wine.

Q. *What becomes of the* CARBONIC ACID, *which is generated by fermentation?*

A. It makes its *escape into the air.*

Q. *Why is* BARLEY MALTED?

A. Because *germination* is produced by the artificial heat; and in germination, the *starch* of the *grain* is converted into *sugar.*

Q. How *is barley malted?*

A. It is *moistened with water,* and *heaped up;* by which means, great heat is produced, which makes the *barley sprout.*

Q. *Why is not the* BARLEY *suffered to* GROW, *as well as* SPROUT?

A. Plants in the *germ* contain more sugar, than in any *other* state; as soon as the germ *puts forth shoots,* the *sugar* of the plant is *consumed,* to support the shoot.

Q. *How is* BARLEY PREVENTED *from* SHOOTING, *in the process of* MALTING?

A. It is put into a *kiln,* as soon as it sprouts; and the heat of the kiln checks or destroys the young shoot.

Q. *What is* YEAST?

A. The foam of beer, or of some similar liquor, in *fermentation.*

Q. *Why is* YEAST *used in* BREWING?

A. Because it consists of a substance called glu'ten, undergoing change; and, therefore, possessing the peculiar property of exciting *fermentation.*

If the glu'ten were not putrefying it could not produce fermentation.

Q. *What is glu'ten?*

A. A tough elastic substance composed of carbon, oxygen, hydrogen, and nitrogen.

Q. *Does* MALT *contain glu'ten?*

A. Yes. The infusion of malt, called "sweet-wort" contains an *abundance* of glu'ten, the yeast (which converts its *sugar* into *al'cohol)* converts this *glu'ten* into *yeast.*

Q. *Why is* YEAST *needful, in order to make malt into* BEER?

A. Because the presence of a putrefying body containing nitrogen is essential, in order to convert sugar into al'cohol.

Q. *What* EFFECT *has yeast upon the* SWEET-WORT?

A. It causes its SUGAR to be converted into *al'cohol* and *carbonic acid*; and its GLUTEN into *yeast*.

Q. *What* CHANGE *is produced in gluten by* PUTREFACTION?

A. Its elements are loosened from their former *conditions of combination*, and re-arranged (with the addition of oxygen from the air) into a *new series*.

Q. *What is the* DIFFERENCE *between* FERMENTATION *and* PUTREFACTION?

A. FERMENTATION is a change effected in the elements of a body composed of carbon, oxygen, and hydrogen *without nitrogen*. PUTREFACTION is a change effected in the elements of a body composed of carbon, oxygen, hydrogen, and *nitrogen*.

Q. *What* NEW COMPOUNDS *are produced by the change called* FERMENTATION?

A. *Al'cohol* and *carbonic acid*.—The al'cohol is still further changed (unless the process be checked) into *ace'tic* acid or *vinegar*.

Q. *What new compounds are produced by the change called* PUTREFACTION ?

A. The carbon, oxygen, hydrogen, and nitrogen, of the original substance (being separated by decomposition) re-unite in the following manner. 1. Carbon and oxygen unite to form *carbonic acid.* 2. Oxygen and hydrogen unite to form *water.* 3. Hydrogen and nitrogen unite to form *ammonia.*

Hartshorn is a solution of ammonia in water.

N.B. When bodies containing sulphur and phosphorus putrefy, the *sulphur* and *phosphorus* unite with *hydrogen,* and form *sulphuretted* and *phosphuretted hydrogen* gases.

Q. *What* BECOMES *of these several products of putrefaction ?*

A. They are all elastic bodies, and *escape into the air.*

N. B. *Water* is elastic and gaseous when in the condition of *vapour.*

Q. *What is the cause of the* OFFENSIVE SMELL, *which issues from putrefying bodies ?*

A. The evolution of *ammonia,* or of *sulphuretted* and *phosphuretted hydrogen* gases; all of which have pungent and offensive odours.

Q. *Why do boiled* EGGS DISCOLOUR *a* SILVER SPOON ?

A. Eggs contain a small portion of *sulphur*, which *unites with the silver* (for which it has a great *affinity)*, and *tarnishes* it.

Both the white and yolk contain sulphur—the latter most abundantly.

Q. *What causes the offensive smell of stale hard boiled* EGGS ?

A. The *hydrogen* of the egg combining with the *sulphur* and phosphorus, form *sulphuretted* and *phosphuretted hydrogen*, both of which gases have an offensive odour.

Of an egg 55 parts are carbon, 16 nitrogen, 7 hydrogen, and the remaining 22 are oxygen, phosphorus, and sulphur.

Q. *Why is it* NOT *needful to put* YEAST *into* GRAPE *juice, in order to produce fermentation ?*

A. Because the grape juice contains (besides its *sugar)*, a sufficient quantity of a nitrogenized substance (like *yeast)* capable of producing fermentation.

Nitrogenized, i. e. containing nitrogen.

Q. *Why do* NOT GRAPES *ferment, while they hang on the* VINE ?

A. Because the *water of the juice* evaporates through the skin, and allows

the grapes to shrivel and dry up, after they are ripe.

Fermentation cannot occur unless the sugar be dissolved in a sufficient quantity of *water.*

Q. *What is the* FROTH *or* SCUM *of fermented* LIQUORS?

A. Putrefying glutinous substances (of a nature similar to yeast), which rise to the surface from their *lightness.*

Q. *Why is* BEER FLAT, *if the cask be open too long?*

A. Because too much of the *carbonic acid gas* (produced by fermentation) is suffered to escape.

Q. *Why are* BEER *and* PORTER *made* STALE *by being exposed to the* AIR?

A. Because too much of the *carbonic acid gas* (produced by fermentation) is suffered to escape.

Q. *Why does* BEER *turn* FLAT, *if the* VENT PEG *be left* OUT *of the tub?*

A. Because the *carbonic acid gas escapes* through the vent hole.

Q. *Why will* NOT *beer* RUN OUT *of the tub, till the* VENT PEG *is taken out?*

A. Because the upward pressure of

the external air (admitted through the *tap)* holds the liquor back,—not being counterbalanced by any pressure of air on the *surface* of the liquid.

The *upward* pressure of air is illustrated by the following simple experiment:—Fill a wine-glass with water; cover the top of the glass with a piece of writing paper; turn the glass upside down, and the water will not run out. The paper is used merely to give the air a medium sufficiently dense to act against.

Q. *Why does the* BEER RUN FREELY, *immediately the* VENT PEG *is taken out?*

A. As soon as the vent peg is taken out, air rushes *through the vent hole* at the *top of the tub,* to counterbalance the air admitted by the tap; in consequence of which, the liquid escapes by its own downward pressure.

Q. *Why does liquor flow reluctantly out of a* BOTTLE *held upside down?*

A. Because the *upward pressure of the air,* prevents the liquor from flowing out.

Q. *Why should a bottle be held* OBLIQUELY, *in order to be emptied of its liquor?*

A. Because *air* will then *flow into the bottle,* and help the liquor out, by *counter-balancing the upward pressure.*

Q. *Why does wine (poured from a bottle* QUICKLY) SPIRT *about, without going into the decanter?*

A. Because it fills the *top of the decanter* (like a *cork*), and leaves *no room* for the air inside *to escape;* the decanter, therefore, (being *full of air*) refuses to admit the *wine.*

Q. *Why does the* EFFERVESCENCE *of soda water and ginger beer so soon go off?*

A. Because the *carbonic acid* (which produced the effervescence) very rapidly *escapes* into the air.

Q. *Why is* BOILED WATER FLAT *and insipid?*

A. Because the whole of the *carbonic acid* is expelled by boiling, and escapes *into the air.*

Q. *Why does* YEAST *make* BREAD LIGHT?

A. Because it produces a species of fermentation on the starch and gluten of flour, as it does in the sugar of malt.

Q. *How does* FERMENTATION *make the* DOUGH RISE?

A. During fermentation, *carbonic acid gas is evolved;* but the sticky texture of the dough will not allow it to

escape, so it *forces up little bladders* all over the dough.

Q. *Why is* DOUGH *placed* BEFORE *the* FIRE?

A. 1st—Because the heat of the fire *increases the fermentation:* and

2ndly—It *expands the gas*, which is confined in the little bladders; in consequence of which, the bladders are *enlarged*, and the dough becomes lighter and more porous.

Q. *Why is* BREAD HEAVY, *if the dough be removed from the fire?*

A. Because the dough *gets cold*, and then the air in the bladders *condenses*—the paste falls,—and the bread becomes close and heavy.

Q. *Whence does the* HEAT *of* FIRE *arise?*

A. The *carbon of fuel* (when heated) *combines* with the *oxygen* of the *air*, and produces *carbonic acid gas:* Again, the *hydrogen* of the *fuel* combining with *other portions* of oxygen, condenses into *water;* by which chemical actions *heat is evolved.*

Q. *Whence does the* HEAT *of our own* BODY *arise?*



A. The *carbon* of the *blood* combines with the *oxygen* of the *air inhaled*, and produces *carbonic acid gas;* which evolves heat in a way similar to burning fuel.

Q. *Whence does the* HEAT *of a* DUNGHILL *arise?*

A. As the *straw*, &c. of the *dunghill* decays, it undergoes *fermentation*, which produces *carbonic acid gas;* and heat is evolved by a species of combustion, (as in the two former cases).

Q. *How does the formation of* CARBONIC ACID *(in all these cases) produce* HEAT?

A. *Carbonic acid* has less power of holding *latent heat*, than *carbon* and *oxygen* have: When, therefore, these elements are changed into carbonic acid, latent heat is given off, and made *sensible*.

Q. *Why do persons throw* LIME *into* BINS *and* SEWERS, *to* PREVENT *their offensive* SMELL, *in summer time?*

A. Because they contain large quantities of *carbonic acid gas*, which readily *combines with lime*, and produces "*carbonate of lime*," which is entirely free from all offensive odour.

Q. *Why should* WATER *(used for washing) be exposed to the air?*

A. Because it is made more *soft* by exposure to the air.

Most spring water holds lime in solution as a *bicarbonate*, in consequence of the presence of abundant carbonic acid. Carbonic acid escapes by exposure to air—and the lime is, consequently, deposited as a carbonate.

Q. *Why is hard* WATER *made more* SOFT *by exposure to air?*

A. 1st—Because it contains certain *mineral salts*, which cause its hardness; and as soon as these salts *subside*, the water becomes more *soft*.

2ndly—Hard water frequently holds *lime* in solution, in consequence of the presence of *carbonic acid*: This carbonic acid *escapes* by exposure to the air; and the *lime* is deposited as a *carbonate*.

Q. *Why is* HARD WATER *more agreeable to* DRINK, *than soft water?*

A. Chiefly because it contains carbonic acid.

Q. *Why is water* FRESH *from the pump more* SPARKLING, *than after it has been drawn some time?*

A. Because water fresh from the

pump contains carbonic acid, which soon escapes into the air, and leaves the water flat and stale.

Q. *Why is* QUICK-LIME *formed by burning chalk and marl in a* KILN?

A. Because the *carbonic acid* (which rendered it *mild)* is driven off by the heat of the kiln, and the lime becomes *quick* or *caustic.*

Q. *What is* MORTAR?

A. Quick-lime mixed with sand and water.

Q. *Wherein does* LIME-STONE *differ in appearance from quick-lime?*

A. LIME-STONE is a hard *rocky* substance; but QUICK-LIME a loose *powder.*

Q. *Why does* MORTAR *become* HARD, *after a few days?*

A. Because the lime *re-imbibes* the carbonic acid of the air, which was *expelled by fire;* and the loose *powder* again becomes as hard, as the original *lime-stone.*

Q. *Why is* MORTAR *adhesive?*

A. When the carbonic acid is expel-

led, the hard lime-stone is *converted into a loose powder*, which (being mixed with sand and water) becomes a *soft and sticky plaster;* but, as soon as it is placed between bricks, it *imbibes carbonic acid again*, and hardens into *lime-stone*.

CHAPTER XX.

CARBURETTED HYDROGEN GAS.

Q. *What is* CHOKE-DAMP?

A. *Carbonic acid gas* accumulated at the bottom of wells and pits. It is called CHOKE damp, because it *chokes* (or suffocates) *every animal* that attempts to *inhale it*. (See p. 266)

It suffocates without getting into the *lungs*, by closing the outer orifice *spasmodically*.

Q. *What is marsh-gas or* FIRE-DAMP?

A. *Carburetted hydrogen gas* accumulated on marshes, in stagnant waters,

and coal pits; it is frequently called "inflammable air."

Q. *What is* CARBURETTED HYDROGEN GAS?

A. *Carbon* combined with *hydrogen.*

Q. *How may* CARBURETTED HYDROGEN GAS *be* PROCURED *on marshes?*

A. By *stirring the mud* at the bottom of any stagnant pool, and collecting the gas (as it escapes upwards) in an inverted glass vessel.

Q. *What is* COAL GAS?

A. *Carburetted hydrogen,* extracted from coals by the heat of *fire.*

Q. *Why is carburetted hydrogen gas called* FIRE-DAMP, *or inflammable air?*

A. Because it very readily *catches fire and explodes,* when a light is introduced to it.

Provided atmospheric air be present.

Q. *Why is carburetted hydrogen gas frequently called* MARSH GAS?

A. Because it is generated in *meadows and marshes* from putrefying vegetable substances.

See ignis fatuus, p. 297.

Q. *What gas is evolved by the* WICK *of a burning* CANDLE?

A. *Carburetted hydrogen gas:* The *carbon* and *hydrogen* of the tallow *combine into a gas* from the heat of the flame; and this gas is called *carburetted hydrogen,* or inflammable air.

Q. *Why do* COAL-MINES *so frequently* EXPLODE?

A. Because the *carburetted hydrogen gas* (which is generated in these mines by the coals) explodes, when a light is incautiously introduced.

Q. *How can miners* SEE *in the coal-pits, if they may* NEVER *introduce a* LIGHT?

A. Sir Humphrey Davy invented a lantern for the use of miners, called "the Safety Lamp;" which may be used without danger.

Q. *Who was* SIR HUMPHREY DAVY?

A. A very clever chemist, born in Cornwall, 1778, and died 1829.

Q. *What kind of thing is the* SAFETY LAMP?

A. It is a kind of lantern, *covered with a fine gauze wire,* instead of glass or horn.

Q. *How does this fine* GAUZE WIRE *prevent an* EXPLOSION *in the coal mine?*

A. It prevents the flame from communicating with the inflammable gas of the mine.

N. B. The interstices of the gauze wire must not exceed the 7th of an inch in diameter.

Q. *Why will not* FLAME PASS THROUGH *very fine wire*-GAUZE?

A. Because the metal wire is a very *rapid conductor of heat;* and when the flame of gas (burning in the lamp) reaches the wire gauze, so much heat is *conducted away by the wire,* that the flame is *extinguished.*

Q. *Does the gas of the* COAL-PIT *get* THROUGH *the wire-gauze* INTO *the* LANTERN?

A. Yes; and the inflammable gas ignites, and burns *inside the lamp:* As soon as this is the case, *the miner is in danger,* and should withdraw.

Q. *Why is the miner in* DANGER, *if the gas ignites, and burns in the* INSIDE *of the safety-lamp?*

A. Because the heat of the burning gas will soon *destroy the wire gauze,* and then the flame (being free) will set fire to the mine.

CHAPTER XXI.

PHOSPHURETTED HYDROGEN GAS.

Q. *From what does the very* OFFENSIVE EFFLUVIA *of* CHURCH-YARDS *arise?*

A. From a gas called PHOSPHURETTED HYDROGEN; which is *phosphorus* combined with *hydrogen gas.*

Q. *What is* PHOSPHORUS?

A. A pale amber-coloured substance, resembling wax in appearance. The word is derived from two Greek words, which mean "to *produce or carry light.*" (Φῶς-Φέρειν).

Q. *How is* PHOSPHORUS OBTAINED?

A. By heating bones to a white heat; by which means, the animal matter and charcoal are *consumed*, and a substance called "*phosphate of lime*" is left behind.

Q. *What is the* PHOSPHATE OF LIME?

A. Phosphorus united to oxygen and lime; when *sulphuric acid* is added, and the mixture heated, the lime is attracted to the acid, and pure *phosphorus* remains.

If powdered charcoal be added, phosphorus may be procured by distillation.

Q. *Of what is the ignitible part of* LUCIFER MATCHES *made?*

A. Of phosphorus; and above 250 thousand lbs. are used every year in London alone, merely for the manufacture of lucifer matches.

Q. *Why does a* PUTREFYING *dead* BODY SMELL *so offensively?*

A. Because *phosphuretted hydrogen gas,* always rises from putrefying animal substances.

The escape of *ammonia and sulphuretted* hydrogen contributes also to this offensive effluvia.

Q. *What is the cause of the* IGNIS FATUUS, *Jack o' Lantern, or Will o' the Wisp?*

A. This luminous appearance (which haunts meadows, bogs, and marshes) arises from the *gas of putrefying animal and vegetable substances;* especially from decaying fish.

Q. *What gases arise from these* PUTREFYING *substances?*

A. *Phosphuretted hydrogen,* from putrefying *animal* substances: and

Carburetted hydrogen, from decaying *vegetable* matters. (*see p.* 293).

Q. *How is the gas of the ignis fatuus* IGNITED *on bogs and meadows?*

A. Impure phosphuretted hydrogen bursts *spontaneously* into flame, whenever it mixes with *air* or *pure oxygen* gas.

If phosphorus is boiled with milk of lime, and the beak of the retort be placed under water, bubbles of phosphuretted hydrogen will rise successively through the water, and (on reaching the surface) burst into flame.

Q. *Why does an ignis fatuus, or Will o' the Wisp,* FLY *from us when we* RUN *to* MEET *it?*

A. When we run *towards* an ignis fatuus, we produce a current of air, which drives the light gas *forwards.*

Q. *Why does an ignis fatuus run* AFTER *us, when we* FLEE *from it in fright?*

A. When we run *away* from the ignis fatuus, we produce a current in the way we run, which *attracts* the light inflammable gas in the *same course.*

Q. *Is not a kind of Jack o'Lantern sometimes produced by an* INSECT?

A. Yes; a swarm of luminous insects sometimes passes over a meadow, and produces an appearance exactly like that of the ignis fatuus.

Q. *May not many* GHOST *stories have risen from some ignis fatuus lurking about church-yards?*

A. Perhaps all the ghost stories (which deserve any credit at all) have arisen from the ignited gas of church-yards lurking about the tombs, to which *fear* has added its own creations.

CHAPTER XXII.

WIND.

Q. *What is* WIND?

A. Wind is *air in motion.*

Q. *What* PUTS *the air in motion, so as to produce* WIND?

A. The principal causes are the *variations of heat and cold;* produced by the succession of *day and night,* and of the *four seasons.*



Q. *What effect has* HEAT *upon the air?*

A. Heat *rarefies* the air, and causes it to *expand.*

Q. *How do you* KNOW *that heat causes the air to* EXPAND?

A. If a bladder *half full of air* (tied tight round the neck), were laid before a *fire,* the air would expand by the heat, so as to *fill* the bladder.

Q. *What* EFFECT *is produced upon air by* RAREFACTION?

A. It is made *lighter,* and *ascends through colder strata;* as a cork (put at the bottom of a basin of water) would rise to the surface.

Q. *How do you* KNOW *that rarefied air* ASCENDS?

A. When a boy sets fire to the cotton or sponge of his balloon, the flame *heats the air;* which becomes *so light,* that it ascends, and *carries the balloon with it.*

Q. *What effect is produced upon* AIR *by* COLD?

A. Air is *condensed by cold,* or squeezed into a smaller compass; in consequence of which, *it becomes heavier,* and descends towards the ground.

Q. *How do you* KNOW *that air is* CONDENSED *by* COLD ?

A. After the bladder is *fully inflated*, (by lying before the fire,) if it be taken away *from* the fire, the bladder will *collapse*, and show that it is not half full.

Q. *What is meant by the bladder* "COLLAPSING ?"

A. The skin becoming *wrinkled, shrivelled, and flabby ;* because there is not sufficient air inside to *fill it.*

Q. *How do you* KNOW *that* CONDENSED *air will* DESCEND ?

A. As soon as the spirit in the cotton is *burnt out*, the air inside the balloon becomes *cold again*, and the balloon *falls* to the earth.

Q. *Does the* SUN HEAT *the* AIR, *as it does the* EARTH ?

A. No ; the air is *not heated* by the *rays of the sun ;* because air (like water) is a very *bad conductor.*

Q. How *is the* AIR HEATED ?

A. By *convection*, thus :—The *sun* heats the *earth*, and the *earth* heats the

air resting upon it; the air thus heated *rises*, and is succeeded by *other air*, which is heated in a similar way; till *all is warmed* by "convective currents."

Q. *What is meant by* "CONVECTIVE CURRENTS *of air?"*

A. Streams of air, heated by the earth, which *rise upwards* and *carry heat with them.*

Q. *Is the air in a* ROOM *in perpetual motion, as the air* ABROAD *is?*

A. Yes; there are always *two currents of air* in the room we occupy; one of *hot* air flowing *out* of the room, and another of *cold* air flowing *into* the room.

Q. *How do you* KNOW, *that there are these* TWO *currents of air in every occupied* ROOM?

A. If I hold a lighted candle near the crevice at the *top of the door,* the flame will be blown *outward* (towards the *hall*); but if I hold the candle at the *bottom of the door,* the flame will be blown *inwards* (into the *room*).

N. B. This is not the case if a *fire* be in the room. When a fire is lighted, an *inward* current is drawn through *all* crevices.

Q. *Why would the flame be blown* OUTWARDS *(towards the* HALL), *if a candle were held at the* TOP *of the door?*

A. Because the air of the room being warmed by the fire, &c., *ascends;* and (floating about the upper part of the room) some of it escapes *through the crevice* at the *top of the door,* producing a current of air *outwards* (into the *hall).*

Q. *Why would the flame be blown* INWARDS *(into the* ROOM), *if the candle were held at the* BOTTOM *of the door?*

A. Because, (after the warm air of the room has ascended to the ceiling, or made its escape into the hall, &c.) a partial *vacuum* is made at the *bottom of the room;* and cold air from the hall *rushes under the door,* to supply the void.

Q. *What is meant by a "partial* VACUUM *being made, at the* BOTTOM *of the* ROOM?"

A. A vacuum means a place *from which the air has been taken:* and a "partial vacuum" means, a place from which a *part* of the air has been taken away. Thus, when the air on the floor *ascends* to the ceiling, a partial vacuum is made on the *floor.*

Q. *And how is the* VACUUM *filled* UP *again?*

A It is filled up by *colder air*, which rushes (under the *door*, and through the *window* crevices) into the room.

Q. *Give me an* ILLUSTRATION?

A. If I dip a pail into a pond and fill it with water, a hole (or vacuum) is made in the pond as *big as the pail;* but the moment I *draw the pail out*, the hole is *filled up* by the water around.

Q. *Show how this illustration* APPLIES?

A. The heated air, which ascends from the bottom of a room, is as much taken away, as the water in the pail; and (as the void was instantly supplied by *other water in the pond)* so the *void of air is supplied* by the air around.

Q. *What is the* CAUSE *of* WIND?

A. The *sun* heats the *earth*, and the *earth* heats the *air* resting upon it; as the warm air ascends, the void is filled up by a *rush of cold air* to the place; and this *rush of air* we call WIND.

Q. *Does the* WIND ALWAYS *blow?*

A. Yes; there is always *some* motion

in the air; but the *violence* of the motion is perpetually varying.

Q. *Does the rotation of the earth upon its axis affect the motion of the air?*

A. Yes in two ways. 1st—As the earth moves round its axis, the thin moveable air is left somewhat *behind*; and, therefore, seems (to a stationary object) to be blowing in the *opposite* direction to the earth's motion: and

2ndly—As the earth revolves, different portions of its surface are continually passing under the vertical rays of the sun.

Q. *What do you mean by "the* VERTICAL RAYS *of the* SUN?"

A. When the sun is in a *direct line* above any place, his rays are said to be "vertical" to that place.

Q. *Illustrate the manner, in which the earth's surface passes under the vertical sun.*

A. Suppose the brass meridian of a globe to represent the vertical rays of the sun; as you turn the globe round, *different parts* of it will pass under the brass rim, in constant *succession*.

Q. *Why is it* NOON-DAY *to the place over which the* SUN *is* VERTICAL ?

A. Because the sun is *half-way* between rising and setting to that place.

Q. *Show how this* ROTATION *of the earth affects the* AIR ?

A. If we suppose the brass meridian to be the vertical sun, the whole column of air *beneath* will be heated by the *noon-day rays;* that part which the sun has *left*, will become gradually *colder and colder;* and that part to which the sun is *approaching*, will grow constantly *warmer and warmer*.

Q. *Then there are* THREE *qualities of air about this spot ?*

A. Yes; the air over the place which has *passed* the meridian is *cooling:* the air under the *vertical sun* is the *hottest:* and the air which is over the place *about to pass* under the meridian, is *increasing in heat*.

See fig. on p 308. The column A (which the sun has passed) is *cooling;* B is under the vertical sun; and C is *increasing in heat.*

Q. *How does this* VARIETY *in the* HEAT *of* AIR *produce* WIND ?

A. The air always seeks to *preserve an equilibrium;* so *cold air* rushes into the *void,* made by the *upward current of the warm air.*

Q. *Why does not the wind* ALWAYS BLOW ONE *way, following the direction of the* SUN?

A. Because the direction of the wind is subject to perpetual interruptions from *hills* and *valleys, deserts, seas,* &c.

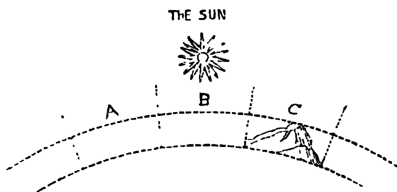
Q. *How can* HILLS *and* MOUNTAINS ALTER *the course of the* WIND?

A. Suppose a wind (blowing from the north) comes to a mountain; as it cannot pass *through it,* it must either rush *back again,* or *fly off at one side,* (as a *marble,* when it strikes against a *wall).*

Q. *Do* MOUNTAINS *affect the wind in any* OTHER *way?*

A. Yes; many mountains are *capped with snow,* and the *warm air* is *condensed,* when it comes in contact with them; but as soon as the *temperature of the wind* is changed, its *direction* may be changed also.

See figure on next page



Suppose A. B. C. to be *three columns of air.* A, the column of air which is *cooling down*; B, the column to which the *sun is vertical*; and C, the column which *is to be heated next.* In this case the *cold* air of A will rush towards B C; because the air of B and C is *hotter* than A. But suppose now C to be a *snow-capped mountain*: As the hot air of B reaches C, it is *chilled;* and (being now *colder* than the air *behind*) it rushes *back again* towards A, instead of following the sun.

Q. *How can the* OCEAN *affect the direction of the* WIND?

A. When the ocean rolls beneath the *vertical sun*, the water is *not made so hot* as the *land;* in consequence of which, the general direction of the wind is directed from tracts of *ocean* towards tracts of *land.*

Q. *Why is not the* WATER *of the sea made so* HOT *by the vertical sun, as the surface of the* LAND?

A. 1st—Because the *evaporation* of the sea is greater, than that of the land:

2ndly—The constant *motion* of the

water prevents the increase of temperature at the surface: and

3rdly—The rays of the sun strike *into* the water; in consequence of which, the immediate *surface* is much less affected.

Q. *Why does the* EVAPORATION *of the sea prevent its surface from being* HEATED *by the vertical sun?*

A. As water *absorbs* heat, by being *converted into vapour;* the surface of the sea is continually *losing heat by evaporation.*

Q. *How does the* MOTION *of the sea prevent its surface from being* HEATED *by the vertical sun?*

A. As one portion is heated, *it rolls away,* and is succeeded by *another;* and this constant motion prevents the *surface* of the sea from being heated, *more than any other* part.

Q. *Do* CLOUDS *affect the* WIND?

A. Yes. As passing clouds screen the direct heat of the sun from the earth, they diminish the *rarefaction of the air also:* and this is *another* cause why neither the strength nor direction of the wind is *uniform.*

Q. *Would the winds blow regularly from east to west, if these* OBSTRUCTIONS *were* REMOVED?

A. Without doubt. If the whole earth were covered with *water*, the winds would always *follow the sun*, and blow uniformly in one direction.

Q. *Do winds* EVER *blow* REGULARLY?

A. Yes; in those parts of the world, which present a large surface of water, as in the Atlantic and Pacific Oceans.

Q. *What are the winds, which blow over the* ATLANTIC *and* PACIFIC *Oceans, called?*

A. They are called "Trade Winds."

Q. *Why are they called* "TRADE WINDS"?

A. Because (as they blow uniformly in one direction) they are very convenient to those, who *carry on trade* by means of these oceans.

Q. *In what* DIRECTION *do the* TRADE WINDS *blow?*

A. That in the *northern* hemisphere blows from the *north-east:* that in the *southern* hemisphere from the *south-east.*

Q. *Why do they not blow from the* FULL NORTH *and* SOUTH?

A. Because currents of air *flowing*

from the poles, give them an *easterly* direction.

Q. *What is the cause of these currents of air from the* POLES *to the* EQUATOR ?

A. The air about the equator (being constantly rarefied by the heat of the sun) *rises;* and cold air from the north and south flows towards the equator, to restore the equilibrium.,

Q. *Is there an* UPPER, *as well as a* LOWER CURRENT, *in the atmosphere ?*

A. Yes; the *upper* current of rarefied air is *from the equator to the poles;* where it is condensed, and returns again to the *equator,* forming the *lower* current.

Q. *Why have these* LOWER CURRENTS *(from the poles to the equator) an* EASTERLY *tendency ?*

A. All the atmosphere revolves *with the earth;* but when a current of air from the *poles* flows towards the *equator,* it comes to a part of the earth's surface, which is moving *faster than itself;* in consequence of which, it is *left behind,* and thus produces the effect of a current moving in the opposite direction.

As the circumference of the earth at the equator is *much*

larger than the circumference of the earth at the poles; therefore, every spot of the earth's *equatorial* surface must move *much faster*, than the corresponding one at the poles.

N.B. As the earth revolves on its axis from west to east, therefore, the air which is carried with it will seem to blow *from the west:* As, however, the current of air from the poles seems to blow in the *opposite* direction, it will seem to blow from the *east* (or to be an *easterly* wind).

Q. *By what means then are the north-east and south-east* TRADE WINDS *produced?*

A. By a combination of the two motions of the *polar currents;* which produces the intermediate directions of the *north-east* and *south-east.*

Q. *Are* BOTH *these motions of the polar currents* REAL?

A. No. The motion from the east to west is only *apparent.* As the earth revolves from *west* to east, the air carried with it will be a *west* wind; but the polar currents seem to blow in the *opposite direction,* merely because they have not *acquired the same velocity.*

Q. *Exemplify this effect with some familiar* ILLUSTRATIONS.

A. The sailing of a ship, by the force of the wind on its sails: The flying of a kite: The motion of fishes: The art

of swimming: and the flight of birds, are all instances of a similar mechanical effect.

Q. *Do trade winds blow from the north-east and south-east* ALL *the* YEAR ROUND?

A. Yes, *in the open sea;* that is, in the Atlantic and Pacific Oceans, for about 30 degs. each side of the equator.

Q. *What do the north-easterly and south-easterly trade winds produce, when they meet near the equator?*

A. A region of *calms*, in which thick foggy air, with sudden showers and thunder-storms, prevail.

Q. *Is this region of calms* FIXED *in its position?*

A. No; it shifts its place, according to the sun's distance, and position in regard to the *equator:* being sometimes entirely to the *north* of the equator, and occasionally reaching as far as 2° *south* of it.

Q. *Do the* TRADE WINDS *blow uniformly from north-east and south-east in the* INDIAN OCEAN?

A. No; nor yet in those parts of the *Atlantic* and *Pacific*, which *verge on the continents.*

Q. *How do the* TRADE WINDS *in the* INDIAN OCEAN *blow?*

A. From April to October a *south-west* wind prevails; from October to April, a *north-east.*

Q. *What are these periodical currents of air (which affect the neighbourhood of the Arabian, Indian, and Chinese Seas) called?*

A. They are called MONSOONS.

Q. *How far do the limits of the* MONSOONS *extend?*

A. They extend from the African Shore to the longitude of New Guinea; and are felt *northward* as far as the parallel of latitude, which crosses the Loochoo Isles.

The Loochoo Isles are about 24° north latitude, and 130° east longitude.

Q. *Why do not the trade winds in the* INDIAN OCEAN *blow south-west from April to October?*

A. Because (as Arabia, Persia, India, and China, are exposed to the enormous heat of their summer sun) the *air* over them *is so rarefied*, that the cold air from the south rushes *towards these nations*, across the *equator;* in consequence of which, a SOUTH-WEST wind is produced for *six months* of the year.

Q. *To what distance does this* SOUTH-WEST *wind prevail?*

A. From 3 degs. south of the equator, to the shores of the Arabian, Indian, and Chinese Seas.

Q. *Why do the trade winds (in the* INDIAN OCEAN) *blow north-east from October to April?*

A. Because when the sun has left the *northern* side of the equator for the *southern,* then the *southern part of the torrid zone* is most heated; and the cold air from the north (rushing towards the southern tropic) is diverted to the NORTH-EAST, where it continues for the *other* six months of the year.

Q. *Are the monsoons as* POWERFUL, *as the trade winds?*

A. They are far *more* so, and very often amount to violent gales.

Q. *Why are the* MONSOONS *more* USEFUL *to the mariner, than the fixed* TRADE WINDS?

A. Because the mariner is able to avail himself of these periodic changes, to go in *one* direction during *one* half of the year, and to *return* in the *opposite* direction during the *other* half.

Q. *How is the change of the monsoons marked?*

A. By an interval of alternating calms and storms.

Q. *Have the winds in* ENGLAND *any general direction throughout the year?*

A. We generally find that *easterly* winds prevail during the *spring* of the year; and that *westerly* winds are most common in the *summer* and *autumn*.

S-West winds are most frequent in July and August. N-East winds in January, March, April, May, and June; but *least* frequent in July, September, and December.

Q. *When are the* WINDS *in* ENGLAND *generally the* HIGHEST?

A. The winds in December and January are generally the highest. Those in February and November the next; and those in August and September are the least boisterous.

Q. *Why are the winds of Europe generally* HIGHEST *in* DECEMBER *and* JANUARY?

A. Because the sun is *furthest south* in those months; and (as the heat in these northern regions rapidly *decreases*) the contrast between our temperature and that of the *torrid zone* is greater in December and January, than in any other two months throughout the year.

Q. *Why does this* CONTRAST *of heat increase the* VIOLENCE *of the* WINDS ?

A. As the air always seeks to *preserve an equilibrium,* therefore, the greater the contrast, the more violent will be the rush of air to *equalize* the two volumes.

Q. *Why are the winds in Europe generally the most* PLACID, *during the months of* SEPTEMBER *and* AUGUST?

A. August and September are our *warmest months*, when we approach nearer to the heat of the torrid zone, than in any other *two months;* therefore, the air (to and from the equator) *moves with less velocity* in our northern hemisphere.

Q. *Show the* GOODNESS *and* WISDOM *of* GOD *in this constant tendency of air to equilibrium.*

A. If the torrid zone were not tempered by cold air from the polar regions, *it would become so hot,* that no human being could endure it. If (on the other hand) the polar regions were never warmed by hot air from the torrid zone, they would soon become *insufferably cold.*

Q. *In what* OTHER *way does the mingling of the polar and equatorial atmosphere act* BENEFICIALLY?

A. In the *equatorial* regions, the great abundance of *vegetable* life is productive of a very large amount of *oxygen :* In the *colder* regions, artificial *fires* and dense masses of *animal life*, produce large quantities of *carbonic acid :* The mingling of the polar and equatorial atmosphere assists in supplying each of these regions with the very gas, in which it would be otherwise defective.

Q. *How does the mingling of the* POLAR *and* EQUATORIAL *atmosphere serve to supply each region with the* GAS *it most requires ?*

A. The *plants* of the EQUATORIAL regions require *carbonic acid ;*—The *animals* of the COLDER regions require oxygen : By mingling of the polar and equatorial atmosphere, the currents of air from the *Poles* carry *carbonic acid* to the equatorial *plants ;* and the aerial currents from the *Equator* carry *oxygen* to the colder regions, for the supply of *animal* life which there abounds.

Q. *Why are* EAST WINDS *in England generally* DRY ?

A. Because (as they come over the

vast continents of Asia and Europe) they absorb *very little water.*

Q. *Why does their imbibing so little water make them* DRY *winds?*

A. Being thirsty when they reach our island, they readily imbibe moisture from the air and clouds; and, therefore, *bring dry weather.*

Q. *Why is the* NORTH WIND *in England generally* COLD?

A. The north wind comes from the *polar regions,* over mountains of snow, and seas of ice; in consequence of which, it is very *cold.*

Q. *Why are* NORTH WINDS *in England generally* DRY *and biting?*

A. As they come from regions *colder than our own,* they are *warmed by the heat of our island;* and (as their temperature is raised) *they absorb moisture* from every thing they touch; in consequence of which, they are both *dry and parching.*

Q. *Why is the* SOUTH WIND *generally* WARM *in England?*

A. The south wind comes over the

hot sandy deserts of Africa, and is heated by the land it traverses.

Q. *Why does the* SOUTH WIND *often bring us* RAIN ?

A. The south wind (being much *heated* by the hot sands of Africa) *imbibes water very plentifully*, as it passes over the Mediterranean Sea and British Channel.

Q *Why does the* SATURATION *of the south wind cause* RAIN ?

A. As soon as it reaches our cold climate it is *condensed*, and can no longer hold all its vapour in suspension; in consequence of which, some of it is deposited as rain.

Q. *Why are* WEST WINDS *in England generally* RAINY ?

A. The west winds come over the *Atlantic Ocean*, and are laden with *vapour*: if, therefore, they meet with the least *chill*, some of the vapour is deposited as rain.

Q. *Why is a fine* CLEAR DAY *sometimes* OVERCAST *in a few minutes?*

A. Because some *sudden change of temperature* has condensed the vapour of the air *into clouds*.

Q. *Why are* CLOUDS *sometimes* DISSIPATED *quite as suddenly?*

A. Because some *dry wind* (blowing over the clouds) has *imbibed their moisture,* and carried it off in invisible vapour.

Q. *Why does a* SOUTH-WEST *wind bring us* RAIN?

A. As it comes from the *torrid zone,* and *crosses the ocean,* the hot wind is *laden with vapour;* and as some of the heat escapes (when it reaches our northern island) the *vapour is condensed,* and precipitated as rain.

Q. *Why does a* NORTH-EAST *wind* RARELY *bring* RAIN?

A. As it comes from a climate *colder than our own,* its capacity for imbibing vapour is *increased,* when it reaches our island; in consequence of which, it *dries the air,* dispels the clouds, and promotes evaporation.

Q. *Why does* WIND *sometimes bring* RAIN, *and sometimes* FINE *weather?*

A. If the wind be *colder than the clouds,* it will condense their vapour into

rain: if the wind be *warmer than the clouds,* it will *dissolve* them, and cause them to disappear.

Q. *Why are* MARCH *winds* DRY?

A. Because they generally blow from the east or north-east; and, therefore, *sweep over the continent of Europe.*

Q. *What is the* USE *of* MARCH *winds?*

A. They *dry the soil* (which is saturated with the floods of February), *break up the heavy clods,* and fit the land for the *seeds* which are committed to it.

Q. *Why is it said, that* "MARCH COMES IN *like a* LION?"

A. Because it comes in with *blustering east winds,* so essential to dry the soil, which would otherwise *rot the seed* committed to it.

Q. *Why does* "MARCH GO OUT *like a* LAMB?"

A. Because the water (evaporated by the high winds) falls again in *showers* to fertilize the earth, and *breaks the violence* of the *winds.*

Q. *Why is it said, that* "*A bushel of* MARCH DUST *is worth the king's ransom?*"

A. Because it indicates that there has

been a continuance of *dry weather;* and unless *March be dry,* the seed will rot in the wet soil.

Q. *Why is it said, "A* DRY *cold* MARCH *never* BEGS BREAD?"

A. Because the *dry cold winds* of March prepare the soil for *seeds;* which germinate, and produce fruit in the autumn.

Q. *Why is it said, that "A* WET MARCH *makes a* SAD *autumn?"*

A. Because (if *March be wet*) so much of the seed *rots* in the ground, that the autumn crops are spoiled.

Q. *Why is it said, that* "MARCH FLOWERS *make* NO *summer* BOWERS?"

A. Because (if the *spring be very mild)* vegetation gets too forward, and is *pinched* by the *nightly frosts,* so as to produce neither fruits nor flowers.

Q. *Why is it said, "A* LATE SPRING *makes a* FRUITFUL YEAR?"

A. Because (if the vegetation of spring be *backward)* the frosty nights will *do no harm;* for the fruits and flowers will not put forth their tender shoots, till the nights become *too warm to injure them.*

Q *Why is it said, that "*APRIL SHOWERS *bring* MAY FLOWERS*?"*

A. Because April showers supply the principal nourishment, on which seeds depend for their development.

Before seeds can germinate, *three* things are essential:—Darkness, Heat, and Moisture.

Q. *Does* RAIN-*water possess any fertilizing properties* BESIDES *that of mere* MOISTURE ?

A. Yes; rain-water contains an abundance of *carbonic acid*, and a small quantity of *ammo'nia;* to which much of its fertilizing power may be attributed.

Ammonia is a compound of nitrogen and hydrogen. Common hartshorn is only ammonia and water.

Q. *Why has God made* NOVEMBER *a very* RAINY *month ?*

A. Because the rain hastens the *putrefaction* of the *fallen leaves;* and this makes the earth fertile.

Q. *Why is there* MORE *rain* FROM SEPTEMBER *to* MARCH, *than from March to September ?*

A. From September to March, the temperature of the air is *constantly decreasing;* on which account, its *capacity for holding vapour* is on the *decrease,* and the vapour is precipitated as rain.

Q. *Why is there* LESS *rain* FROM MARCH *to* SEPTEMBER, *than from September to March?*

A. From March to September, the temperature of the air is *constantly increasing;* on which account, its *capacity for holding vapour* is on the *increase,* and very little is precipitated as rain.

Q. *Why is the* RISING SUN *in summer accompanied with a* BREEZE?

A. Because the heat of the rising sun *stops the radiation of heat* from the earth, and *warms its surface.*

Q. *How does this* WARMTH *produce a* BREEZE?

A. The air (resting on the earth's surface) is *warmed by contact*—ascends upwards,—and *colder air rushes in* to fill up the void; which is the cause of the *morning* breeze.

Q. *Why is there often an* EVENING BREEZE *during the summer months?*

A. The earth *radiates heat at sun-set,* and the air is cooled down quickly by contact: this condensation causes a *motion in the air,* which is the evening breeze.

Q. *Why are* TROPICAL ISLANDS *always subject to a* SEA-*breeze every* MORNING; *(i. e. a breeze blowing from the sea to the land)?*

A. The solar rays are unable to heat the surface of the *sea,* as they do the *earth;* therefore, the *air resting* on the *earth* is more *heated,* than the *air resting* on the *sea;* and the colder sea air blows *inland* to restore the equilibrium.

Q. *Why is the* LAND BREEZE UNHEALTHY?

A. Because it is frequently loaded with exhalations from *putrefying animal* and *vegetable* substances.

Q. *Why is the* SEA BREEZE *fresh and* HEALTHY?

A. Because it passes over the fresh sea, and is *not* laden with noxious exhalations.

It is *healthy,* therefore, to walk on the sea-beach before ten o'clock in the morning; but *unhealthy* after sun-set.

Q. *Why is there generally a fresh breeze from the* SEA *(in English watering places) during the summer and autumn* MORNINGS?

A. As the *land* is *more heated by the sun,* than the *sea;* therefore, air resting on the *land* is hotter, than air resting on the *sea;* in consequence of which, cooler sea

air glides *inland,* to restore the equilibrium.

Q. *Why does the* SEA BREEZE *feel* COOL?

A. As the sun cannot make the surface of the *sea* so hot as the surface of the *land;* therefore, the air which blows from the sea, feels *cooler than the air of the land.*

Q. *Why are* TROPICAL ISLANDS *subject to a* LAND BREEZE *every* EVENING; *(i. e. a breeze blowing from the land towards the sea)?*

A. The *surface of land* cools down *faster* (after sun-set) than the surface of the *sea:* in consequence of which, the air of the cold land *is condensed,—sinks down,*—and spreads itself into the warmer *sea air,*—causing the LAND BREEZE.

Q. *Why is the* LAND BREEZE COOL?

A. As the surface of the land is cooled at sun-set *quicker than the surface of the sea;* therefore, the seaman feels the air from the land to be chill.

Q. *Why is the* TEMPERATURE *of* ISLANDS *more* EQUABLE, *than that of* CONTINENTS?

A. Because the *water* around the island *absorbs* the extreme heat of

summer; and *gives out* heat to mitigate the extreme cold of winter.

Q. *Why does the sea round an island* GIVE OUT *heat in winter?*

A. Unless the *sea be frozen* (which is rarely the case), it is warmer than the frozen land; and, therefore, the warmth of the sea air helps to mitigate the intense cold of the land air.

Q. *Why are there* WAVES *in the sea?*

A. The wind (acting on the surface of the sea) *piles up ridges of water*, which leave behind an *indentation:* as the water on all sides rushes to *fill up this indentation*, the disturbance spreads on all sides, and billow rolls after billow.

Q. *Why does* WIND *in England generally feel* COLD?

A. Because a *constantly changing surface* comes in contact with our body, to draw off its heat.

Q. *Why is a* ROOM *(even without a fire) generally* WARMER, *than the* OPEN AIR?

A. As the air in a room is *not subject to much change*, it soon becomes of the same temperature as our skin, and no longer feels cold.

Q. *Why do we generally feel* COLDER *out-of-doors?*

A. Because the air (which surrounds us) *is always changing;* and as fast as *one* portion of air has become warmer by contact with our body, *another colder portion* surrounds us to absorb more heat.

Q. *Why are* HOT FOODS *made* COOL *by* BLOWING *them?*

A. Blowing causes the air (which covers the hot food) to *change more rapidly;* in consequence of which, the hot air is *quickly blown away,* and gives place to fresh *cold air.*

Q. *Why do ladies* FAN THEMSELVES *in hot weather?*

A. By the action of the fan, *fresh particles of air* are perpetually brought in contact with the face; and every fresh particle of air *absorbs some heat* from the skin.

Q. *Does the fan* COOL *the* AIR?

A. No; it makes the air *hotter,* by imparting to it the heat *out of the face:* but it cools the *face* blown upon, by transferring its heat to the *air.*

Q. *Is the* AIR *in* SUMMER *ever so hot as our bodies?*

A. No, not in England. In the hottest day in summer, the air of England is 15 or 20 degrees cooler, than the human body.

Q. *How fast does wind travel?*

A. A gentle breeze goes at about the rate of 5 miles an hour. A high wind from 20 to 60. A hurricane from 80 to 100 miles an hour.

Q. *How is the* VELOCITY *of* WINDS *ascertained?*

A. By observing the velocity of the clouds; and by an instrument for the purpose.

This instrument is called an ANEMOMETER.

Q. *How is the* VELOCITY *of the* CLOUDS *ascertained?*

A. By observing the speed of their shadow along the ground; which is found (in a high wind) to vary from 20 to 60 miles an hour.

Q. *Why is there always a strong* DRAUGHT *through the* KEYHOLE *of a door?*

A. As the air in the room we occupy

is *warmer* than the air in the hall, therefore, the air from the hall *rushes through the keyhole* into the room, and causes a draught.

Q. *Why is there always a strong* DRAUGHT UNDER *the* DOOR, *and through the crevice on each side?*

A. The cold air *rushes from the hall* under the door, &c. into the room,—to supply the *void*, caused in the room by the escape of warm air up the chimney, &c.

Q. *Why is there always a* DRAUGHT *through the* WINDOW *crevices?*

A. The external air (being colder, than the air of the room we occupy) rushes through the window crevices *to supply the deficiency*, caused by the escape of air up the chimney, &c.

Q. *Why is there more* DRAUGHT *if you open the* LOWER SASH *of a window, than if you open the* UPPER *sash?*

A. If the *lower* sash be open, the *cold external air* will rush more freely *into the room;* but if the *upper* sash be open, the *heated air of the room* will *rush*

out; and (of course) there will be less draught.

Q. *By which means is the* ROOM *better* VENTILATED; *by opening the lower or the upper sash?*

A. A room is better *ventilated* by opening the *upper sash;* because the hot vitiated air (which always ascends towards the ceiling) *can escape more easily.*

Q. *By which means is a* HOT ROOM *more quickly* COOLED—*By opening the upper or the lower sash?*

A. A hot room is *cooled more quickly* by opening the *lower sash;* because the cold air can enter more freely by an *under* current, than by one *higher up.*

Q. *Why does* WIND DRY *damp* LINEN?

A. Because dry wind (like a dry sponge) imbibes the particles of vapour from the surface of the linen, as fast as they are formed.

Q. *Which is the* HOTTEST PLACE *in a church, chapel, or theatre?*

A. The gallery.

Q. *Why is the* GALLERY *of all public places* HOTTER, *than the* LOWER *parts of the building?*

A. Because the heated air of the

building *ascends;* and all the *cold air* (which can enter through the doors and windows) *keeps to the floor*, till it has become heated.

Q. *Why do* PLANTS *often grow out of* WALLS *and* TOWERS?

A. Because sometimes, the *wind* blows the seed there with the dust; and sometimes, *birds* (flying over) drop the seed, which they had formerly eaten.

CHAPTER XXIII.

BAROMETER.

Q. *What is a* BAROMETER?

A. A weather-glass, or instrument to measure the variations of the *weight* of the *air;* by means of which *variations*, we may judge what weather may be expected.

Q *What is a* THERMOMETER?

A. An instrument to show how *hot or cold* anything is.

Q. *What is the* DIFFERENCE *between a* THERMOMETER *and a* BAROMETER ?

A. In a THERMOMETER the mercury is *sealed up from the air;* and rises or falls, as the varying *temperature* of the air expands or contracts it: but

In a BAROMETER the mercury is left *exposed* (or open) *to the air;* and rises or falls, as the varying *weight* of the air presses upon the open column.

Q. *If the mercury of the thermometer be* SEALED UP *from the air, how can the air* AFFECT *it?*

A. The heat of the air (passing *through the glass tube* into the mercury), causes it to *expand;* and rise in the tube accordingly.

Q. *Why is the* TUBE *of a* BAROMETER *left* OPEN ?

A. That the air may *press upon it* freely; and as this pressure is *more* or *less*, the mercury *rises or falls* in the tube.

The top of the tube must be a "*vacuum*"; otherwise the pressure of the external air upon the lower part of the column cannot affect the mercury.

Q. *How can weather be affected by the* WEIGHT *of the air?*

A. When air is *moist,* or filled with vapour, it is *lighter* than usual; and the column of mercury stands *low:*

When air is *dry* and free from vapour, it is *heavier* than usual; and the mercury stands *high:* Thus the barometer (by showing the variations in the *weight of the air)* indicates the changes of the *weather* also.

Q. *Why can you tell (by looking at a* BAROMETER) *what* KIND *of* WEATHER *it will be?*

A. Because the mercury in the tube *rises and falls,* as the air becomes heavier or lighter: and we can generally tell by the *weight* of the air, what kind of weather to expect.

Q. *Does the* WEIGHT *of the air* VARY MUCH?

A. Yes; the atmosphere in England varies as much as *one-tenth part* more or less.

Q. *What* USE *is a* BAROMETER *to sailors?*

A. It warns them to *regulate their ships,* before squalls come on.

Q. *How can a* BAROMETER *warn* SAILORS *to regulate their* SHIPS?

A. As the barometer indicates when *wind, rain,* or *storm* is at hand, the sailor can make his ship trim before it overtakes him.

Q. *Are there any* RULES, *which can be depended on?*

A. Yes; there are *ten special rules* to direct us how to know the changes of weather, by marking the mercury of a barometer.

Q. *What is the* 1ST SPECIAL RULE *with regard to the barometer?*

A. The barometer is *highest of all* during a *long frost*; and it generally rises with a *north-east wind.*

Q. *Why is the barometer* HIGHEST *of all during a long* FROST?

A. Because a long frost *condenses the air very greatly*; and the more that air is *condensed*, the greater is its *pressure* on the mercury of the barometer.

Q. *Why does the barometer generally* RISE *with a* NORTH-EAST *wind?*

A. Because NORTH-EAST winds make the air both *cold and dry:* the air, therefore, is both *condensed*, and *without vapour.*

Q. *What is the* 2ND SPECIAL RULE *with regard to the barometer?*

A. The barometer is *lowest of all*

during a *thaw, which follows a long frost:* it generally falls with SOUTH and WESTERLY winds.

Q. *Why does the barometer fall* LOWEST *of all, at the* BREAKING UP *of a long* FROST?

A. 1st—Because the air (which had been much *dried* by the frost) *absorbs the moisture* of the fresh warm current of wind from the south or south-west: and

2ndly—The air (which had been much *condensed* by the frost) is suddenly *expanded* by the warm wind, which is introduced.

Q. *Why does the barometer fall very low with* SOUTH *and* WEST *winds?*

A. Because SOUTH and WEST winds come heavily *laden with vapour;* and *vaporized* air is lighter than *dry air.*

Q. *What effect has* WIND *on the mercury?*

A. The barometer is *high,* when the wind blows between the EAST and the NORTH; but it is *low,* when the wind blows between the SOUTH and the WEST.

Q. WHY *do these winds affect the mercury of a barometer?*

A. Because the pressure of the air is

increased by *cold winds,* and diminished by *warm* ones.

Q. *Why is pressure of the air* INCREASED *with cold winds from the* NORTH ?

A. Because (when the air is *cooled* by winds from the north and east) it *contracts,* and *warmer* air flows in from all sides to fill up the vacuum; in consequence of which, the volume of the air is increased, and the barometer *falls.*

Q. *Why is the* PRESSURE *of the air* DIMINISHED *by warm winds from the* SOUTH *and* WEST?

A. Because (when the air is *heated* by south and west winds) it *ascends,* and flows away in all directions; in consequence of which, the volume is *diminished,* and the mercury *falls.*

Q. *What is the* 3RD SPECIAL RULE *with regard to the barometer?*

A. While the barometer stands above 30, the air must be very *dry,* or very *cold,* or perhaps *both,*—and *no rain* may be expected.

Q. *Why will there be* NO RAIN, *if the* AIR *be very* DRY ?

A. If the air be very *dry,* it will

absorb moisture, and not part with it in *rain.*

Q. *Why will there be* NO RAIN *if the* AIR *be very* COLD ?

A. If the air be very *cold,* it is *so much condensed,* that it has already parted with as much moisture, as it can spare.

Q. *What is the* 4TH SPECIAL RULE *with regard to the barometer ?*

A. When the barometer stands *very low* indeed, there will never be *much* rain ; although a *fine day* will seldom occur at such times.

Q. *What kind of* WEATHER *is there likely to be, when the barometer is* UNUSUALLY LOW ?

A. *Short heavy showers,* with sudden *squalls of wind* from the *west.*

Q. *Why will there be* VERY LITTLE RAIN *if the barometer be* UNUSUALLY LOW ?

A. Because the air must be very *warm,* or very *moist,* or perhaps *both.*

Q. *Why will there be little or no rain, if the* AIR *be very* WARM ?

A. If the air be very warm, it will have a tendency to *imbibe more moisture,* and not to part with what it has.

Q. *Why will there be little or no rain, if the air be* MOIST, *and the barometer remain very* LOW?

A. If the air be ever so moist, rain will never fall till *cold air* has been introduced to *condense the vapour;* and the moment that the *cold* air is introduced, the barometer will *rise.*

Q. *What is the* 5TH SPECIAL RULE *with regard to the barometer?*

A. In summer-time; (after a long continuance of fair weather) the barometer will *fall gradually* for 2 or 3 days before *rain* comes; but if the fall of the mercury be very *sudden,* a *thunder-storm* is at hand.

Q. *What is the* 6TH SPECIAL RULE *with regard to the barometer?*

A. When the sky is cloudless, and seems to promise fair weather, if the barometer be *low,* the face of the sky will soon be suddenly *overcast.*

Q. *What is the* 7TH SPECIAL RULE *with regard to the barometer?*

A. Dark dense clouds will pass over *without rain,* when the barometer is *high;* but if the barometer be *low,* it

will often rain *without* any appearance of clouds.

Q. *What is the* 8TH SPECIAL RULE *with regard to the barometer?*

A. The *higher* the barometer, the greater is the probability of *fair weather.*

Q. *Why is the barometer* HIGH *in* FINE *weather?*

A. Because the air in fine weather contains *very little vapour.* The *drier* the air, the *higher* does the mercury of the barometer rise.

Q. *What is the* 9TH SPECIAL RULE *with regard to the barometer?*

A. When the mercury is in a *rising* state, *fine* weather is at hand; but when the mercury is in a *sinking* state, *foul* weather is near.

Q. *Why does the mercury* RISE *at the approach of* FINE *weather?*

A. Because the air is becoming more *dry*; and, therefore, its *pressure is greater.*

Q. *Why does the mercury* SINK *at the approach of* FOUL *weather?*

A. Because the air is *laden with vapour*, or *disturbed by wind*.

Q. *Why does* VAPOUR *in the air make the mercury* SINK?

A. Because vaporized air is *lighter than dry air;* and, therefore, its *pressure is less* on the mercury of the barometer.

Q. *What is the* 10TH SPECIAL RULE *with regard to the barometer?*

A. If (in frosty weather) it *begins to snow*, the barometer generally rises to 30, where it remains as long as the snow continues to fall; if, after this, the weather *clear up*, you may expect *very severe cold*.

Q. *How can you know if the* MERCURY *of the barometer be* RISING?

A. If the top of the column be *convex* (i. e. higher in the *middle*, than at the *sides)*, it is in a *rising state*.

Q. *How can you tell if the* MERCURY *of the barometer be* FALLING?

A. If the top of the column be *concave* (i. e. *hollow* in the middle), it is in a *falling state*.

Q. *Why is the mercury* CONVEX, *when it is* RISING?

A. The parts of the mercury in contact with *the tube,* are delayed by the glass; in consequence of which, the *middle* part *rises faster* than the *sides;* and the surface is CONVEX.

Q. *Why is the mercury* CONCAVE, *when it is* FALLING?

A. The parts of the mercury in contact with *the tube,* are delayed by *capillary attraction;* in consequence of which, the *middle* part *sinks faster* than the *sides;* and the surface is CONCAVE.

Q. *What effect does a* THUNDER-STORM *produce on the weather?*

A. Thunder is generally *preceded by hot* weather, and *followed by cold* and showery weather.

Q. *What effect does a* SUDDEN CHANGE *of temperature produce on the weather?*

A. A great and sudden change (either from hot to cold, or from cold to hot) is generally followed *by rain within 24 hours.*

Q. *Why is a sudden* CHANGE *from* HOT *to* COLD *followed by* RAIN?

A. The cold *condenses the air* and its

vapour; which (being condensed) *falls in rain.*

Q. *Why is a sudden* CHANGE *from* COLD *to* HOT *followed by* RAIN?

A. Because the air is quickly *saturated* with *moisture;* and as soon as *night* comes on, the temperature is lowered again, and some of the abundant moisture falls in rain.

Q. *Why is the air quickly* SATURATED *with* MOISTURE, *when* HEAT *rapidly succeeds* COLD?

A. Because the evaporation (which was checked by the cold) is *carried on very rapidly,* in consequence of the *diminished* pressure of the air.

N. B. The *less the pressure* of the air, the more *rapid the evaporation* of moisture.

Q. *When does the barometer* VARY MOST?

A. In winter time.

Q. *Why does the barometer vary* MORE *in* WINTER, *than in* SUMMER *time?*

A. Because the *difference* of temperature between the torrid and temperate zones is much *greater;* and produces a greater disturbance in the state of the air.

Q. *When does the barometer* VARY LEAST?

A. In summer time.

Q. *Why does the barometer vary* LESS *in* SUMMER, *than in* WINTER *time?*

A. Because the temperature of our island is *so nearly equal* to that of the torrid zone, that its state is *not much* disturbed by interchange of currents.

Q. *Have* HEAT *and* COLD *any effect on the barometer?*

A. No, not of themselves; but because *cold* weather is generally either *dry*, or *rough* with north-east winds, therefore the mercury *rises* in cold weather: And because warm weather is often *moist* or *fanned* by south-west winds, therefore, the mercury *sinks* in warm weather.

Q. *Why is the mercury of a barometer* LOWER *in the* TORRID, *than in the* FRIGID *zone?*

A. Because the warm air of the torrid zone contains much more *vapour*; than the condensed air of the frigid zone; and the *moister* the air, the *less* is its pressure.

Q. *In what* MONTHS *is the barometer* HIGHEST?

A. In May and August; next to these, in June, March, September, and April.

Q. *In what* MONTHS *is the barometer* LOWEST?

A. In November and February; then in October, July, December, and January.

Q. *What are the* DRIEST *months?*

A. March and June; then May and August; then April and November.

Q. *What are the* WETTEST *months?*

A. October and February; then July and September; then January and December.

Q. *Why is there* LESS *wet from* MARCH *to* AUGUST, *than there is from August to March?*

A. Because the heat is *constantly increasing;* and the capacity of the air to absorb and retain moisture increases likewise.

Q. *Why is there* MORE *wet from* AUGUST *to* MARCH, *than there is from March to August?*

A. Because the heat is *constantly decreasing;* and the capacity of the air to retain moisture decreases also; so that (although it often rains) yet the air is always on the point of saturation.

Q. *Why does the mercury of a barometer* RISE *in a* FROST?

A. Because frost *condenses the air;* and condensed air is heavier, than rarefied air.

Q. *Why does the mercury of a barometer* FALL *in a* THAW?

A. Because the air is filled with *vapour*.

Q. *What does a* SUDDEN *rise or fall of the barometer indicate?*

A. If the *rise* be sudden, fine weather will not continue long:

If the *fall* be sudden, foul weather will not continue long.

Q. *What sort of weather may we expect, if the barometer be very* FLUCTUATING?

A. If the mercury fluctuates much, the weather will be very *changeable* and *unsettled*.

THE FALL OF THE BAROMETER.

In very *hot* weather, the fall of the mercury denotes *thunder*.

Except in very hot weather, the sudden falling of the barometer denotes high wind.

In *frosty* weather, the fall of the barometer denotes *thaw*.

If *wet* weather happens *soon* after the fall of the barometer, expect but *little* of it.

In *wet* weather if the barometer falls, expect much wet.

In *fair* weather, if the barometer falls much and *remains* low, expect much wet in a few days, and probably *wind*.

N. B. The barometer sinks lowest of all for wind and rain together; next to that for wind, (except it be an east or north east wind).

THE RISE OF THE BAROMETER.

In *winter*, the rise of the barometer presages *frost.*

In *frosty* weather, the rise of the barometer presages *snow.*

If *fair* weather happens *soon* after the rise of the barometer, expect but *little* of it.

In *wet* weather, if the mercury rises high and *remains* so, expect continued *fine* weather in a day or two.

In wet weather, if the mercury rises suddenly very high, fine weather will not last long.

N. B. The barometer rises highest of all for north and east winds; for all *other* winds it sinks.

THE BAROMETER UNSETTLED.

If the motion of the mercury be *unsettled,* expect unsettled weather.

If it stand at "MUCH RAIN" and rise to "CHANGEABLE," expect *fair weather of short continuance.*

If it stand at "FAIR" and fall to "CHANGEABLE," expect *foul* weather.

N.B. Its motion *upwards* indicates the approach of fine weather; its motion *downwards* indicates the approach of foul weather.

CHAPTER XXIV.

SNOW. HAIL. RAIN.

Q *What is* SNOW?

A. The condensed vapour of the air *frozen,* and precipitated to the earth.

Q *What is the* CAUSE *of* SNOW?

A. When the air is nearly saturated with vapour, and condensed by a current of air *below freezing point;* some of the vapour is condensed, and frozen into snow.

A few years ago, some fishermen (who wintered at Nova-Zembla), after they had been shut up in a hut for several days, *opened the window;* and the cold external air rushing in, instantly condensed the air of the hut, and its vapour fell on the floor *in a shower of snow.*

Q. *Why does* SNOW *fall in* WINTER *time?*

A. Because the sun's rays are too *oblique* to heat the surface of the earth; and (as the earth has no heat to radiate into the air) the air is very cold.

Q. *What is the cause of* SLEET?

A. When flakes of snow (in their descent) pass through a bed of air *above freezing point,* they partially melt; and fall to the earth as half-melted snow, or sleet.

Q *What is the* USE *of* SNOW?

A. To keep the earth *warm,* and to *nourish* it.

Q. WHY *can snow keep the* EARTH WARM?

A. Because it is a very *bad conductor;* in consequence of which, the earth, (which

is covered with snow), very rarely descends *below freezing point*, even when the air is 15 or 20 degrees colder.

Q. WHY *is* SNOW *a* BAD CONDUCTOR *of heat and cold?*

A. Because *air* is confined and entangled among the crystals, and *air* is a very *bad* conductor; when, therefore, the earth is covered with snow, it cannot throw of its heat by radiation.

Q. *Tell me the words of the* PSALMIST (cxlvii. 16.) *respecting snow; and explain what he means.*

A. The Psalmist says—"The Lord giveth snow like wool:" and he means not only that snow is as *white as wool,* but that it is also as *warm as wool.*

Q. *Why is* WOOL WARM?

A. Because *air* is entangled among the fibres of the wool; and air is a very *bad conductor.*

Q. *Why is* SNOW WARM?

A. Because *air* is entangled among the crystals of the snow; and air is a very *bad conductor.*

Q. *Why does* SNOW NOURISH *the earth?*

A. Because the *contrast* between the *night and day* is very great. The hot air *absorbs moisture* very abundantly during the day; but when it is *condensed* by the cold night (being unable to retain the same quantity of moisture), some of it falls in rain.

CHAPTER XXV.

WATER.

Q. *Of what is* WATER *composed?*

A. Water is composed of *two gases*, oxygen and hydrogen.

In 9 lbs. of water, 8 are oxygen, and 1 is hydrogen.

Q. *Why is* WATER FLUID?

A. Because its particles are kept separate by *latent heat;* but when a certain quantity of this latent heat is driven out, *water becomes solid,* and is called ice.

Q. *How can* WATER *be converted into a* GAS?

A. By increasing its *latent heat,* the

particles of water are again subdivided into *invisible steam.*

Q. *Why is* PUMP *water called* "HARD *water*"?

A. Because it is laden with foreign matters, and will not readily *dissolve substances* immersed in it.

Q. *What makes* PUMP-*water* HARD?

A. When it filters through the earth, it becomes impregnated with *sulphate of lime,* and many other impurities, from the *earths and minerals* with which it comes in contact.

Q. *Why is it difficult to* WASH *our* HANDS *clean with* HARD *water?*

A. Because the *soda of the soap* combines with the *sulphuric acid* of the hard water,—and the *oil of the soap* with the *lime,* and floats in flakes on the top of the water.

N. B. Sulphate of lime consists of sulphuric acid and lime.

Q. *Why is it difficult to wash in* SALT WATER?

A. Because salt water contains *muriatic acid;* and the *soda of soap* combines with the *muriatic acid of the salt water,* and produces a cloudiness.

Q. *Why does a* BLACK HAT *turn* RED *at the* SEA SIDE?

A. The *muriatic acid* of the sea-water disturbs the *gallic acid* of the black dye, and turns it red.

Q. *Of what is* SOAP *made?*

A. Of kelp (or the ashes of sea-weed dried and burnt in a pit) mixed with oil or fat.

YELLOW SOAP is made of whale-oil, soda, and resin. SOFT SOAP is made of oil and potash. HARD SOAP of oil and soda.

Q. *Why does* WATER CLEAN *dirty* LINEN?

A. Because it *dissolves* the stains, as it would dissolve salt.

Q. *Why does* SOAP *greatly* INCREASE *the cleansing power of water?*

A. Because many of the stains are of a *greasy nature;* and soap has the power of *uniting with greasy* matters, and rendering them soluble in water.

Q. *Why is* RAIN WATER SOFT?

A. Because it is not impregnated with *earths and minerals.*

Q *Why is it* MORE EASY *to* WASH *with* SOFT *water, than with* HARD?

A. Because it unites freely with the

soap, and *dissolves* it; instead of decomposing it, as hard water does.

Q. *Why do* WOOD ASHES *make* HARD *water* SOFT?

A. 1st—Because the *carbonic acid* of the *wood ashes* combines with the *sulphate of lime* in the hard water, and converts it into *chalk:* and

2ndly—The ashes convert some of the soluble salts of the water into insoluble, and throw them down as a sediment; in consequence of which, the water remains more pure.

Q. *Why has* RAIN *water such an* UNPLEASANT SMELL, *when it is collected in a rain water-tub or tank?*

A. Because it is impregnated with *decomposed* organic matters, washed from roofs, trees, or the casks in which it is collected.

Q. *Why does* WATER MELT SUGAR?

A. Because very minute particles of water insinuate themselves into the *pores* of the sugar, by capillary attraction; and force the crystals apart from each other.

Q. *Why does* WATER MELT SALT?

A. Because very minute particles of water insinuate themselves into the *pores* of the salt, by capillary attraction; and force the crystals apart from each other.

Q. *Why does melted* SUGAR *or* SALT *give a* FLAVOUR *to* WATER ?

A. Because the sugar or salt (being disunited into very minute pieces) *floats* about the water, and mixes with every part.

Q. *Why does* HOT *water melt sugar and salt* QUICKER *than* COLD *water ?*

A. Because the *heat* of the water, entering the pores of the sugar or salt, opens a passage for the water.

Q. *Why is* SEA-*water heavy and brackish ?*

A. 1st—Because it contains *mines of salt* at the bottom of its bed:

2ndly—It is impregnated with *bituminous matter*, which is brackish: and

3rdly—It contains many *putrid substances,* which increase its brackishness.

Q. *Why is* NOT RAIN-*water* SALT, *although most of it is evaporated from the* SEA ?

A. Because *salt* will not *evaporate ;* and, therefore, when sea-water is turned to vapour, its *salt* is left behind.

Q. *Why does* STAGNANT *water* PUTREFY?

A. Because leaves, plants, insects, &c. are decomposed in it.

Q. *Why is* STAGNANT *water full of* WORMS, EELS, *&c.?*

A. Because numberless insects *lay their eggs* in the leaves and plants, which float on the surface; these eggs are soon hatched, and produce swarms of worms, eels, and insects.

Q. *Why are* FLOWING *waters* FREE *from these* IMPURITIES?

A. 1st—Because the motion of running water prevents its *fermentation:*

2ndly—It dissolves the *putrid substances,* which happen to fall into it: and

3rdly—It casts on the *bank* (by its current) such substances, as it cannot dissolve.

Q *Why does* RUNNING *water* OSCILLATE *and* WHIRL *in its current?*

A. 1st—Because it *impinges* against its *banks,* and is perpetually diverted from its forward motion: and

2ndly—Because the *centre* of a river flows faster, than its sides.

Q. *Why do the* SIDES *of a river flow more* TARDILY, *than its* CENTRE?

A. Because they *rub* against the *banks,* and are delayed in their current thereby.

Q. *Why does* SOAPY *water* BUBBLE?

A. Because the soap makes the *water tenacious;* and prevents the bubbles from *bursting,* as soon as they are formed.

Q. *Why will not water bubble* WITHOUT SOAP?

A. Because it is not tenacious enough to hold together the *bubbles* that are formed.

Q. *When* SOAP BUBBLES *are blown from a pipe, why do they* ASCEND?

A. Because they are *filled with warm breath,* which is lighter than air.

CHAPTER XXVI.

ICE.

Q. *What is* ICE?

A. FROZEN WATER. When the air

is reduced to 32 degrees of heat, water will no longer remain in a *fluid state.*

Q. *Why is* SOLID ICE LIGHTER *than* WATER?

A. Because water *expands* by freezing; and as the *bulk* is *increased,* the *gravity* must be *less.*

Nine cubic inches of water become *ten* when frozen.

Q. *Why do* EWERS BREAK *in a* FROSTY NIGHT?

A. Because the water in them *freezes;* and as the water is *expanded* by frost, it bursts the ewers, to make room for its increased volume.

Q. *Why does it not expand* UPWARDS *(like boiling water),* *and* RUN OVER?

A. Because the *surface* is frozen first; and the frozen surface acts as a *plug,* which is more difficult to burst, than the earthen ewer itself.

Q. *Why do* TILES, STONES, *and* ROCKS, *often* SPLIT *in winter?*

A. Because the moisture in them *freezes;* and, by its expansion, *splits the solid mass.*

Q. *In winter time,* FOOT-MARKS *and* WHEEL-RUTS *are often covered with an icy* NET-WORK, *through the interstices of which the soil is clearly seen,*—WHY *does the water freeze in* NET-WORK?

A. The water in these hollows freezes first at the *sides* of the foot-prints: other crystals gradually shoot across the water, and would cover the whole surface, if the earth did not *absorb* the water, before it had time to freeze.

Q. *In winter time, these* FOOT-MARKS *and* WHEEL-RUTS *are sometimes covered with a perfect* SHEET *of ice, and not an icy net-work,—Why is* THIS?

A. The *air being colder*, and the *earth harder* (than in the former case), the *entire surface* of the foot-print is frozen over, before the water is absorbed by the earth.

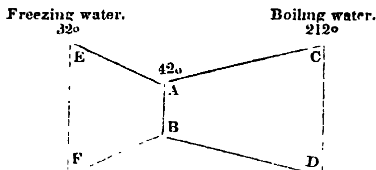
Q. *Why is not the ice* SOLID *in these ruts?—* WHY *is there only a very thin* FILM *or* NET-WORK *of ice?*

A. Because the earth *absorbs the water*, and leaves the icy *film behind.*

Q. *Does not water expand by* HEAT, *as well as by* COLD?

A. Yes; it expands as soon as it is more than 42 degrees, *till it boils;* and then it flies off in steam.

See figure on next page.



Here AB measures the bulk of a portion of water at 42 degrees.

It goes on increasing in bulk to CD, when it boils.
It also goes on increasing in bulk to EF, when it freezes.

Q. *Why do* WATER-PIPES *frequently* BURST *in* FROSTY *weather?*

A. Because the water in them *freezes*; and as the water *expands by frost*, it bursts the pipes, to make room for its increased volume.

Q. WHEN *does* WATER *begin to* EXPAND *from cold?*

A. Water (which is wisely ordained by God to be an *exception* to a very general rule) *contracts* till it is reduced to 42 degrees, and then it *expands till it freezes*.

Water freezes at 32°.

Q. WHY *does water expand when it freezes?*

A. Because it is converted into *solid crystals*, which *do not fit close*, like the particles of water.

Q. *Why is the water at the* BOTTOM *of a river* NEVER FROZEN?

A. Because, when water is colder than 42 degrees, it instantly *ascends* to the surface; and (if it freezes) *floats there,* till it is melted.

Q. *Show the* WISDOM *of* GOD *in this wonderful exception to a general law.*

A. If ice were *heavier than water,* it would *sink;* and a river would soon become a *solid block of ice,* which could never be dissolved.

Q. *Why does not the cold* ICE *on the* SURFACE *of a river* CHILL *the water* BENEATH, *and make it freeze?*

A. 1st—Water is a *very bad conductor,* and is heated or chilled by CONVECTION only:

2ndly—If the ice on the surface were to communicate its *coldness* to the water beneath, the water beneath must communicate its *heat to the ice,* and the ice would instantly *melt:* and

3rdly—The ice on the surface acts as a *shield,* to prevent the cold air from *penetrating the river,* to freeze it below the mere crust.

Q. *Why does* WATER FREEZE *at the* SURFACE *first?*

A. Because the surface is in *contact with the air*, and the air *carries away its heat.*

Q. *Why does the coat of ice grow* THICKER *and* THICKER, *if the frost* CONTINUES?

A. Because the *heat* of the water (immediately below the frozen surface) *passes through the pores of the ice* into the *cold air.*

Q. *Why then are not* WHOLE RIVERS FROZEN *(layer by layer), till they become solid ice?*

A. Because water is so *slow* a conductor, that our frosts never continue *long enough*, to convert a whole river into a solid mass of ice.

Q. *Why does not* RUNNING *water freeze so* FAST *as* STILL *water?*

A. 1st—Because the motion of the current *disturbs the crystals*, and prevents their forming into a continuous surface: and

2ndly—The heat of the *under* surface is communicated to the *upper* surface by the *rolling of the water.*

Q. *When* RUNNING *water is* FROZEN, *why is the* ICE *generally very* ROUGH?

A. Because little flakes of ice are first formed and *carried down* the stream, till they met some *obstacle* to *stop* them; *other* flakes of ice (impinging against them) are arrested in like manner; and the *edges* of the different flakes *overlapping* each other, *make the surface rough.*

Q. *Why do* SOME *parts of a* RIVER FREEZE LESS *than* OTHERS?

A. Because *springs* issue from the bottom, and (as they bubble upwards) *thaw the ice,* or make it thin.

Q. *When persons* FALL *into a* RIVER *in winter time, why does the* WATER *feel remarkably* WARM?

A. Because the *frosty air* is at least 10 or 12 degrees *colder* than the water.

The water below the surface is at least 42°; but the air 32°, or even less.

Q. *Why is* SHALLOW *water* FROZEN QUICKER *than* DEEP *water?*

A. Because (as the *whole volume* of water must be cooled to 42 degrees, before the *surface can be frozen*) it will take a longer time to cool down a *deep* bed of water, than a *shallow* one.

Q. *Why is* SEA-WATER RARELY FROZEN?

A. 1st—Because the *mass of water is so great,* that it requires a very long time to cool the whole volume down to 42 degrees:

2ndly—The *ebb and flow* of the sea interfere with the cooling influence of the air: and

3rdly—*Salt* never freezes, till the surface is cooled down 25 degrees *below freezing point.*

Q. *Why do some* LAKES RARELY *(if ever)* FREEZE?

A. 1st—Because they are *very deep:* and

2ndly—Because their water is supplied by *springs,* which bubble from the bottom.

Q. *Why does the* DEPTH *of the water* RETARD *its* FREEZING?

A. As the *whole volume of water* must be reduced to 42 degrees, before the *surface will freeze,*—the *deeper* the water, the *longer* it will be before the whole volume is thus reduced.

Q. *Why do* SPRINGS *at the bottom of a lake* PREVENT *its* FREEZING?

A. Because they keep continually sending forth *fresh water,* which prevents the lake from being reduced to the necessary degree of coldness.

Q. *Why is it* COLDER *in a* THAW, *than in a* FROST?

A. When frozen water is *thawed,* it *absorbs* heat from the *air,* &c. to melt its ice; in consequence of which, the cold of the air is greatly increased.

Q. *Why is it* WARMER *in a* FROST, *than in a* THAW?

A. When water *freezes,* it gives out its *latent heat,* in order that it may be converted into *solid ice;* and, as much heat is liberated from the water into the atmosphere, the air feels *warmer.*

Q. *Why does* SALT DISSOLVE ICE?

A. Water freezes at 32°, but salt and water will not freeze till the *air* is 25 degrees *colder:* if, therefore, salt be added to frozen water it becomes *liquid,* unless the thermometer stands below 7°, (which it never does in our island).

Q. *Will any thing do* INSTEAD *of* SALT?

A. Yes; any *acid,* such as sulphuric, nitric, &c.

Q. *Why are* SALT *and* SNOW, *mixed together, colder than* SNOW?

A. When *salt* is mixed with snow, it *dissolves the crystals* into a fluid; and whenever a solid is converted to a liquid, *heat is absorbed,* and the cold made more intense.

Q. *Why does* FROST *make the* EARTH CRACK?

A. During the warm weather the earth *absorbs* abundance of *moisture,* which the winter *freezes:* and (as water *expands* by frost) the expanding water thrusts the particles of earth apart from each other, and leaves a chink or crack behind.

Q. *Show the* WISDOM *of* GOD *in this arrangement.*

A. These *cracks* in the earth let in the air, the dew, the rain, and many gases favourable to vegetation.

Q. *Why does the* EARTH CRUMBLE *in* SPRING?

A. In spring the *ice* of the clods *dissolves,* and the particles of earth (which had been held apart by the expanded ice) are left *unsupported,* and tumble into minute parts, (because their *cement is dissolved).*

Q. *Why does* MORTAR CRUMBLE *away in* FROST?

A. Because it was not *dried in the warm weather;* therefore, its moisture *freezes, expands,* and thrusts the particles of the mortar away from each other; but (as soon as the frost goes) the *water condenses,* and leaves the mortar full of cracks and chinks.

Q. *Why does* STUCCO PEEL *from a* WALL *in* FROSTY *weather?*

A. Because the stucco was not *dried in the warm weather;* therefore, its moisture *freezes, expands,* and thrusts its particles away from the wall; but as soon as the water condenses again by the thaw, the stucco (being unsupported) *falls by its own weight.*

Q. *Why cannot* BRICKLAYERS *and* PLASTERERS *work in* FROSTY *weather?*

A. Because the bricks and plaster would *start from their position,* as soon as the *frost* came and expanded the mortar.

Q. *Why do* BRICKLAYERS COVER *their work with* STRAW *in spring and autumn?*

A. Because straw is a non-conductor, and prevents the mortar of their new work from *freezing*, during the cold nights of spring and autumn.

Q. *Why are* WATER-PIPES *often covered with* STALL-LITTER *in winter time?*

A. Because straw (being a non-conductor) prevents the *water of the pipes from freezing*, and the *pipes from bursting*.

Q. *Why are delicate* TREES *covered with* STRAW *in* WINTER?

A. Because straw (being a non-conductor) prevents the *sap of the tree* from being frozen.

Q. *Can* WATER *be* FROZEN *in any way* BESIDES *by frosty weather?*

A. Yes; in very many ways. For example—a bottle of water wrapped in *cotton*, and frequently *wetted with ether*, will soon freeze.

Q. *Why would* WATER FREEZE *if the bottle were kept constantly wetted with* ETHER?

A. Because *evaporation* would carry off the heat of the water, and reduce it to the *freezing point.*

Q. *Why does* ETHER *freeze under the* RECEIVER *of an* AIR-*pump, when the air is exhausted?*

A Because *evaporation* is very greatly increased by the *diminution of atmospheric pressure;* and the ether freezes by evaporation.

FREEZING MIXTURES.

1. If nitre be dissolved in water, the heat of the liquid will be reduced 16 degrees.

2. If 5 oz. of nitre, and 5 of sal-ammoniac (both finely powdered) be dissolved in 19 oz. of water, the heat of the liquid will be reduced 40 degrees.

3. If 3 lbs. of snow be added to 1 lb. of salt, the mixture will fall to 0° (or 32 degrees below freezing point).

The two following are the coldest mixtures yet known.—

1. Mix 3 lbs. of muriate of lime with 1 lb. of snow.

2. Mix 5 lbs. of diluted sulphuric acid with 4 lbs. of snow.

Q. *Why is it more easy to* SWIM *in the* SEA, *than in a* RIVER?

A. Because the *specific gravity* of salt water is *greater* than that of fresh; and, therefore, it *buoys* up the swimmer better.

Q. *How do cooks ascertain, if their* BRINE *be* SALT ENOUGH *for pickling?*

A. They put an *egg into their brine.* If the egg *sinks,* the brine is *not strong enough;* if the egg *floats,* it *is.*

Q. *Why will the* EGG SINK *if the brine be* NOT STRONG *enough for pickling?*

A. As an egg is *heavier* than water, it will *sink* if immersed therein; but if as much *salt* be added as the water can dissolve, the egg will *float.*

Q. WHY *will the* EGG FLOAT *in strong* BRINE?

A. Because the specific gravity of *salt and water* is greater than that of water *only.*

Q. *Why do persons* SINK *in water, when they are* UNSKILFUL SWIMMERS?

A. Because they struggle to keep their *heads out of water.*

Q. *How does struggling "to keep their* HEAD OUT *of water" make them* SINK?

A. When the head is thrown back boldly into the water, (as the body is altogether *lighter,*) the mouth is kept *above the surface,* and the swimmer is able to breathe:

But when the skull is kept *above the surface* of the water, the chin and mouth sink *beneath* it, and the swimmer is suffocated.

This may be illustrated thus:—If a piece of wood be of such specific gravity, that only *two square inches* can float

out of water; it is manifest, that if two *other* inches are raised *out*, the two *former* inches must be plunged *in*. The body (in floating) resembles this piece of wood—If two square inches of the *face* float out of the water, the swimmer can breathe; but if part of the *back* and *crown* of the head be forcibly raised above the surface, a proportionable quantity of the face must be plunged *in;* and the mouth is covered.

Q. *Why can* QUADRUPEDS *swim* MORE EASILY *than* MAN?

A. 1st—Because the *trunk* of quadrupeds is *lighter* than water; and this is the greatest part of them: and

2ndly—The *position* of a beast (when swimming) is a *natural* one.

Q *Why is it* MORE DIFFICULT *for a* MAN *to swim, than for a* BEAST?

A. 1st—Because his body is more *heavy* in proportion, than that of a beast: and

2ndly—The *position* and muscular action of a *man* (when swimming) differ greatly from his ordinary habits; but beasts swim in their *ordinary* position.

Q. *Why can* FAT *men* SWIM *more* EASILY *than* SPARE *men?*

A. *Fat is lighter than water;* and the *fatter* a man is, the more *buoyant* will he be.

Q. *How are* FISHES *able to* ASCEND *to the* SURFACE *of water?*

A. Fishes have an *air-bladder* near their abdomen: when this bladder is *filled with air*, the fish increases in size; and (being lighter) ascends through the water to its surface.

Q. *How are fishes able to* DIVE *in a minute to the* BOTTOM *of a stream?*

A. They *expel the air* from their air-bladder; in consequence of which, their *size is diminished*, and they sink instantly.

CHAPTER XXVII.

LIGHT.

Q. *What is* LIGHT?

A. Rapid undulations of a fluid called ether, which are made sensible to the eye, by striking on the optic nerve.

See p. 47.

Q. *How* FAST *does* LIGHT TRAVEL?

A. Light travels so fast, that it would

go eight times round the earth, while a person counts "ONE."

Q. *Does* ALL *light travel equally fast?*

A. Yes; the light of the sun,—the light of a candle,—or the light from houses, trees, and fields.

Q. *Where does the* LIGHT *of* HOUSES, TREES, *and* FIELDS, *come from?*

A. The light of the *sun* (or of some lamp or candle) is *reflected* from their *surfaces.*

Q. *Why are* SOME *surfaces* BRILLIANT *(like glass and steel), and* OTHERS DULL, *like lead?*

A. Those surfaces which *reflect the most light,* are the most *brilliant;* and those which *absorb* light are *dull.*

Q. *What is meant by* REFLECTING LIGHT?

A. Throwing the rays of light *back again,* from the surface on which they fall.

Q. *What is meant by* ABSORBING LIGHT?

A. Retaining the rays of light on the surface on which they fall; in consequence of which, their presence is not made sensible by *reflection.*

Q. *Why can a* THOUSAND *persons* SEE *the* SAME OBJECT *at the same time?*

A. Because it throws off from its surface an infinite number of rays in all directions; and one person sees *one* portion of these rays, and another person *another*.

Q. *Why is the* EYE PAINED *by a* SUDDEN *light?*

A. Because the nerve of the eye is *burdened with rays,* before the pupil has had time to contract.

Q. *Why does it give us* PAIN, *if a* CANDLE *be brought suddenly towards our* BED *at night time?*

A. In the dark, the *pupils* of the eyes *dilate* very much, in order to *admit more rays.* When a candle is brought before them, the enlarged pupils allow the nerves behind to be *overladen with rays,* which causes pain.

Q. *Why* CAN *we* BEAR *the candle-light after a few moments?*

A. Because the pupil *contracts again* almost instantly; and adjusts itself to the quantity of light, which falls upon it.

Q. *Why can we* SEE NOTHING, *when we leave a* WELL-LIGHTED *room, and go into the* DARKER ROAD *or street?*

A. Because the pupil (which *contracted* in the bright room) does not *dilate instantaneously;* and the contracted pupil is not able to collect rays enough (from the darker road or street) to enable us to see before us.

Q. *Why do we* SEE BETTER, *when we get* USED *to the dark?*

A. Because the pupil *dilates* again, and allows more rays to pass through its aperture; in consequence of which, we see more distinctly.

Q. *If we look at the* SUN *for a few moments, why do all* OTHER *things appear* DARK?

A. Because the pupil of the eye (which was *very much contracted* by looking at the sun) is *too small* to collect sufficient rays from *other objects,* to enable us to distinguish their colours. *(See* "accidental colours.")

Q. *If we watch a bright* FIRE *for a few moments, why does the* ROOM *seem* DARK?

A. Because the pupil of the eye (which was very much *contracted* by looking at the fire) is *too small* to collect

sufficient rays from the objects around, to enable us to distinguish their colours.

Q. *Why can we see the* PROPER COLOUR *of every object again, after a few minutes?*

A. Because the pupil dilates again, and accommodates itself to the light around.

Q. *Why can* TIGERS, CATS, *and* OWLS, *see in the* DARK?

A. Because they have the power of *enlarging the pupil of their eyes*, so as to collect several scattered rays of light; in consequence of which, they can *see distinctly*, when it is not light enough for us to see *any thing at all.*

Q. *Why do* CATS *and* OWLS SLEEP *almost all* DAY?

A. As the pupil of their eyes is *very broad*, daylight *fatigues* them; so, they close their eyes for relief.

Q. *Why do* CATS *keep* WINKING, *when they sit before a* FIRE?

A. As the pupil of their eyes is *very broad*, the light of the fire *pains* them; and they keep shutting their eyes, to relieve the sensation of too much light.

Q. *Why do* TIGERS, CATS, OWLS, *&c.* PROWL *by* NIGHT *for prey?*

A. As these animals cannot see distinctly in *strong daylight,* they *sleep* during the *day:* and as they can see clearly in the *dark,* they prowl then for prey.

Q. *Why do* GLOW-WORMS *glisten by* NIGHT *only?*

A. Because the light of day is *so strong,* that it *eclipses* the feeble light of a glow-worm: in consequence of which, glow-worms are *invisible by day.*

Q. *Why can we* NOT *see the* STARS *in the* DAY-TIME?

A. Because the light of day is so powerful, that it *eclipses the feeble light of the stars:* in consequence of which, they are invisible by day.

Q. *Why can we see the* STARS *even at* MID-DAY, *from the bottom of a deep* WELL?

A. As the rays of the sun never come *directly over a well* (in these regions), but the rays of many *stars* do; therefore, the light from those stars (in such a situation) is more clear, than the light of the *sun.*

Q. *What is the* USE *of* TWO EYES, *since they present only one image of any object?*

A. The use of two eyes is to *increase the light,* or take in *more rays of light* from the object looked at; in order that it may appear *more distinct.*

Q. *Why do we* NOT *see things* DOUBLE, *with* TWO EYES?

A. 1st—Because the *axis of both eyes is turned to one object;* and, therefore, the *same impression* is made on the ret'ina of *each eye:* and

2ndly—The nerves (which receive the impression) have *one point of union,* before they reach the brain.

This is not altogether satisfactory, although it is the explanation generally given. The phenomenon probably is rather psychological, than material.

Q. *Why do we* SEE OURSELVES *in a* GLASS?

A. The rays of light from our face *strike against the surface of the glass,* and (instead of being absorbed) *are reflected,* or sent back again to our eye.

Q. *Why are the rays of light* REFLECTED *by a* MIRROR?

A. Because they cannot *pass through the impenetrable metal* with which the

back of the glass is covered; so they *rebound back*, just as a *marble* would do, if thrown against a wall.

Q. *When a marble is rolled towards a wall, what is the path* THROUGH WHICH IT RUNS *called?*

A. The line OF INCIDENCE.

Q. *When a marble* REBOUNDS *back again, what is the path it* THEN *describes called?*

A. The line OF REFLECTION.

See figure on p. 388. If AB be the line of incidence, then BC is the line of reflection: and *vice versa*.

Q. *When the light of our face goes* TO *the* GLASS, *what is the path through which it goes* CALLED?

A. The line of *incidence*.

Q. *When the light of our face is reflected* BACK *again from the mirror, what is this* RETURNING *path called?*

A. The line of *reflection*.

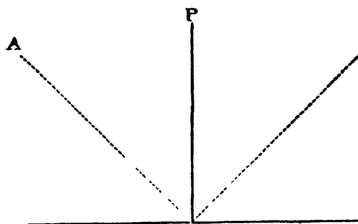
Q. *What is the* ANGLE *of incidence?*

A. The angle between the line of *incidence* and the *perpendicular*.

Q. *What is the* ANGLE *of reflection?*

A. The angle between the line of *reflection* and the perpendicular.

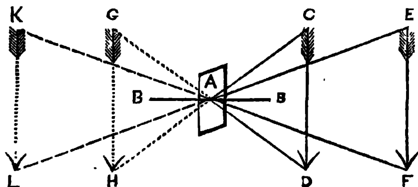
See figure on next page.



Let SS be any surface, PB a perpendicular to it.—If a marble were thrown from A to B, and bounded back to C; then ABP would be called the angle of *incidence*, and CBA the angle of *reflection*.

Q. *Why does our reflection in a mirror seem to* APPROACH *us, as we walk* TOWARDS *it; and to* RETIRE FROM *us, as* WE *retire?*

A. Because the lines and *angles of incidence* are always *equal* to the *lines* and *angles of reflection;* in consequence of which, the *image* will always seem to be as far *behind* the mirror, as the *real object* is *before* it.



Suppose A to be a mirror—CA, EA and DA, FA the lines of incidence; then GA, KA and HA, and LA are the lines of reflection. When the arrow is at CD, its image will appear at GH, because line CA=GA, and line DA=HA; and also the angle CAB=angle GAB, and angle DAB=HAB. For a similar reason, if the arrow were at EF the image would seem to be at KL.

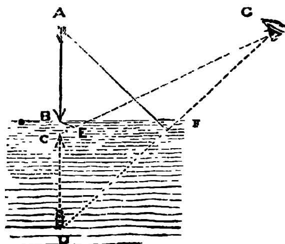
Q. *Why can a man see his* WHOLE PERSON *reflected in a* LITTLE MIRROR, *not* 6 *inches in length?*

A. Because the *lines and angles of incidence* are always equal to the *lines and angles of reflection;* in consequence of which, his image will seem to be as far *behind* the mirror as his person is *before* it.

Take the last figure—CD is much larger than the mirror AB; but the head of the arrow C is reflected obliquely behind the mirror to G; and the barb D appears at H.—Why? Because line CA=AG and line DA=HA; also the angle CAB=angle GAB, and angle DAB=HAB.

Q. *Why does the* IMAGE *of any object in* WATER *always appear* INVERTED?

A. Because the *angles of incidence* are always equal to the *angles of reflection.*



Here the arrow head A strikes the water at F, and is reflected to D; and the barb B strikes the water at E, and is reflected to C.

If a spectator stands at G, he will see the reflected lines CE and DF, produced as far as G.

It is very plain that the more elevated object A will strike the water, and be projected from it more perpendicularly, than the point B; and, therefore, the image will seem inverted.

Q. *When we see our* REFLECTION *in* WATER, *why do we seem to* STAND *on our* HEAD?

A. Because the *angles of incidence* are always equal to the *angles of reflection.*

Suppose our head to be at A, and our feet at B; then the shadow of our head will be seen at D, and the shadow of our feet at C. (*See last figure p.* 389).

Q. *Why do* WINDOWS *seem to* BLAZE *at* SUN-RISE *and* SUN-SET?

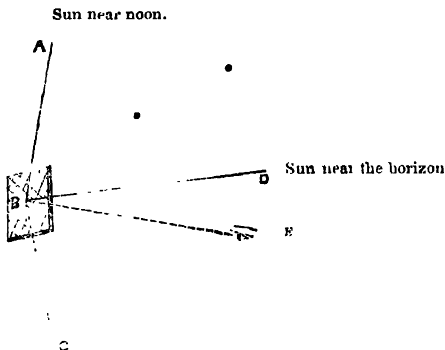
A. Because glass is a good *reflector of light;* and the rays of the sun (striking against the window glass) are *reflected,* or thrown back.

Q. *Why do* NOT *windows reflect the* NOON-DAY *rays also?*

A. They do, but the reflection is *not seen.*

Q. *Why is the reflection of the* RISING *and* SETTING *sun seen in the window, and* NOT *that of the* NOON-DAY *sun?*

A. As the angle of *incidence* always equals the *angle of reflection*, therefore the rays of the noon-day sun enter the glass *too obliquely* for their reflection to be seen.



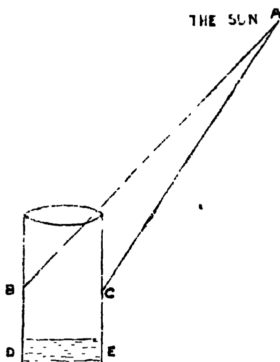
Here AB represents a ray of the noon-day sun striking the window at B; its reflection will be at C:

But DB (a ray of the rising or setting sun) will be reflected to E (the eye of the spectator).

Q. *Why can we not see the* REFLECTION *of the* SUN *in a* WELL, *during the day-time?*

A. Because the rays of the SUN *fall so obliquely*, that they *never reach* the

surface of the water at all, but strike against the brick sides.

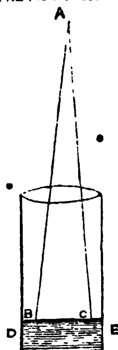


Let BDEC be the well, and DE the water.
The ray AB strikes against the brick-work *inside* the well; and
The ray AC strikes against the brick-work *outside* the well.
None will ever touch the water DE.

Q. *Why are the* STARS REFLECTED *in a* WELL, *although the* SUN *is* NOT ?

A. The rays of those STARS which pass nearly *over head,* will not fall so obliquely into the well, as the rays of the

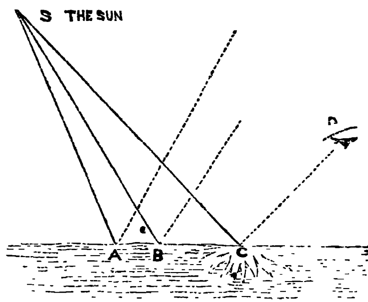
sun and moon ; in consequence of which, they may be reflected from the water there.



Here the star's rays AB, AC, both strike the water DE, and are reflected by it.

Q. *In a sheet of water at noon, the sun appears to shine upon only* ONE *spot, and all the* REST *of the water seems* DARK,—WHY *is this ?*

A. Because the rays (which fall at various degrees of obliquity on the water) are reflected at *similar angles ;* but as only those which *meet the eye of the spectator* are visible, all the water will appear dark, but *that one spot.*



Here of the rays SA, SB, and SC, only the ray SC meets the eye of the spectator D.

The spot C, therefore, will appear luminous to the spectator D, but no other spot of the water ABC.

Q. *On a lake of water the* MOON *seems to make a* PATH *of light towards the eye of the spectator, while all the* REST *of the lake seems* DARK,—WHY *is this?*

A. By DAY, the glare of the sun upon the lake eclipses the *feebler* reflections, and leaves only the most luminous spot visible to the spectator; but

By NIGHT, the lake is in deep *shadow*, and the *whole path* of light is distinctly visible.

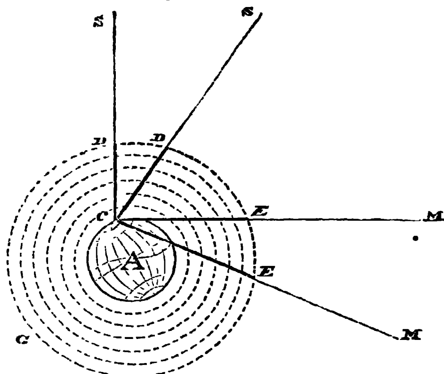
Q. *Why are* MORE STARS *visible from a* MOUNTAIN, *than from a* PLAIN?

A. As the air *absorbs* and *diminishes*

light, the *higher* we ascend, the *less light* will be absorbed.

Q. *Why does the* SUN *seem* LARGER *at his* RISING *and* SETTING, *than it does at* NOON?

A. Because the earth is surrounded by air, which acts like a *magnifying glass*; and when the sun is near the horizon (as its rays pass through *more* of this air), it appears larger.



Here SC represents a ray of the sun at noon, and MC a ray of the sun near the horizon.

DEG represents the air or atmosphere around the earth.

Because EC is longer than DC, therefore the rays of the sun at M pass through *more air*, than the rays of the sun at S: and the effect of refraction in magnifying is increased.

Q. *Why does the* RISING *and* SETTING MOON *appear so much* LARGER, *than after it is risen higher above our heads?*

A. Because the earth is surrounded by air, which acts like a *magnifying glass;* and when the moon is near the horizon (as its rays pass through more of this air) it appears larger. (See last figure p. 395).

Q. *When* CANDLES *are* LIGHTED, *we* CANNOT SEE *into the* STREET *or road,*—WHY *is this?*

A. 1st—Because glass is a reflector, and throws the candle-light *back into the room* again; and

2ndly—The pupil of the eye (which has become *contracted* by the light of the room) is *too small* to collect rays enough from the dark street, to enable us to *see into it.*

Q *Why do we often see the* FIRE REFLECTED *in our parlour* WINDOW *in winter time?*

A. Because glass is a *good reflector;* and the rays of the fire (striking against the window-glass) *are reflected back into the room again.*

Q. *Why do we often see the image of our* CANDLES *in the window, while we are sitting in our parlour?*

A. Because the rays of the candle

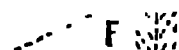
(striking against the glass) are *reflected back into the room:* and the *darker* the night, the *clearer* the reflection.

Q. WHY *is this reflection more clear, if the external* AIR *be* DARK?

A. Because the reflection is not then *eclipsed* by the brighter rays of the sun, *striking on the other side of the window.*

Q. *Why is the* SHADOW *of an object (thrown on the wall)* LARGER *and larger, the* CLOSER *the object is held to the* CANDLE?

A. Because the rays of light *diverge* (from the flame of a candle) *in straight lines,* like lines drawn from the centre of a circle.





B

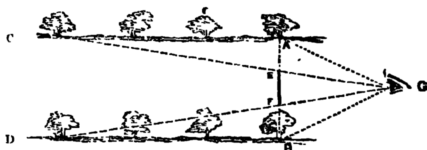
Here the arrow A held close to the candle, will cast the

M a

shadow BF on the wall. while the same arrow held at C, would cast only the little shadow DE.

Q. *When we enter a long* AVENUE *of* TREES, WHY *does the avenue seem to get* NARROWER *and narrower, till the two sides appear to* MEET ?

A. Because the *further the trees are off*, the more *acute will be the angle*, that any opposite two make with our eye.



Here the width between the trees A and B will seem to be as great as the line AB:

But the width between the trees C and D will seem to be no more than EF.

Q. *In a long straight* STREET, WHY *do the houses on the opposite sides seem to* APPROACH NEARER *together, as they are more* DISTANT ?

A. Because the more *distant the houses* are, the more *acute will be the angle*, which any opposite two make with our eye.

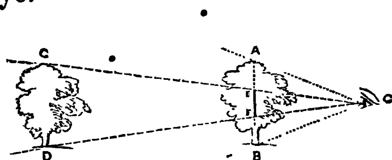
Thus in the last figure—

If A and B were two houses at the *top* of the street, the street would seem to be as wide as the line AB:

And if C and D were two houses at the *bottom* of the street, the street there would seem to be no wider than EF.

Q. *In an* AVENUE, WHY *do the* TREES *seem to be* SMALLER, *as their distance increases?*

A. Because the *further the trees are off,* the more *acute will be the angle* made by their perpendicular height with our eye.



Here the first tree AB will appear the height of the line AB; but the last tree CD will appear only as high as the line EF.

Q. *In a long straight* STREET, WHY *do the houses seem to be* SMALLER *and smaller, the* FURTHER *they are* OFF?

A. Because the *further any house is off,* the more *acute will be the angle* made by its perpendicular height with our eye.

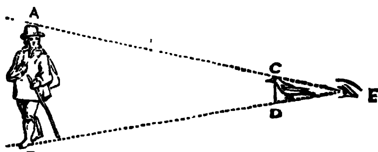
Thus in the last figure—

If AB be a house at the top of the street, its perpendicular height will be that of the line AB.

If CD be a house at the bottom of the street, its perpendicular height will appear to be that of EF.

Q. *Why does a man on the* TOP *of a* MOUNTAIN, *or church spire, seem to be no* BIGGER *than a* CROW?

A. Because the angle made by the *perpendicular height of the man* (at that distance) *with our eye*, is no bigger than that made by a *crow close by*.

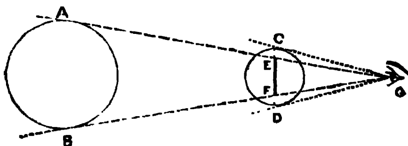


Let AB be a man on a distant mountain or spire, and CD a crow close by:

The man will appear only as high as the line CD, which is the height of the crow.

Q. *Why does the* MOON *appear to us so much* BIGGER *than the* STARS, *though in fact it is a great deal* SMALLER?

A. Because the moon is *very much nearer to us*, than any of the stars.



Let AB represent a fixed star, and CD the moon.

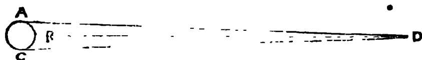
AB, though much the larger body, will appear no bigger than EF; whereas the moon (CD) will appear as large as the line CD to the spectator G.

The moon is 240,000 miles from the earth, not quite a quarter of a *million* of miles. The nearest fixed stars are 20,000,000,000,000. (i. e. 20 billions.)

If a ball went 500 miles an hour, it would reach the moon in twenty days: but it would not reach the nearest fixed star in 4,500,000 years. Had it begun, therefore, when Adam was created, it would be no further on its journey, than a coach (which has to go from the Land's End, Cornwall, to the most northern parts of Scotland) after it has past about three-quarters of a mile.

Q. *Why does the* MOON *(which is a sphere)* APPEAR *to be a* FLAT *surface?*

A. Because it is *so far off*, that we cannot distinguish any difference, between the *length of the rays* which issue from the *edge*, and those which issue from the *centre*.



The rays AD and CD appear to be no longer, than the ray BD; but if all the rays seem of the same length, the part B will not seem to be *nearer* to us than A and C; and therefore ABC will look like a flat or straight line.

The rays AD and CD are 240,000 miles long.

The ray BD is 238,910 miles long.

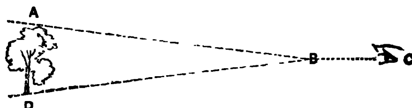
Q. *Why do the* SUN *and* STARS *(which are spheres) appear to be* FLAT *surfaces?*

A. Because they are such an *immense way off*, that we can discern *no difference of length*, between the rays which issue from the *edge*, and those which issue from the *centre* of these bodies.

The rays AD and CD appear no longer than BD; and as B appears to be no nearer than A or C, therefore ABC must all seem equally distant; and ABC will seem a flat or straight line. (*See last figure, p.* 401).

Q. *Why does* DISTANCE *make an object* INVISIBLE?

A. Because the angle (made by the *perpendicular height* of the distant object with our eye) is so very *acute*, that *one* line of the angle *merges in the other.*



Here the tree AD would not be visible to the spectator C, even if he were to approach as far as B; because no visible perpendicular can be inserted between the two lines AC, DC, till after the point B is past; when the tree will appear like a very little speck.

Q. *Why do* TELESCOPES *enable us to* SEE *objects* INVISIBLE *to the naked eye?*

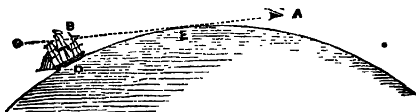
A. Because they gather together

more luminous rays from obscure objects, than the *eye* can; and form a bright image of them in the tube of the telescope, where they are magnified.

As many times as the dimensions of the *object-glass*, exceed the dimensions of the *pupil of the eye*; so many times the penetrating *powers* of the telescope, will exceed that of the naked eye.

Q. *When a* SHIP *(out at sea) is approaching the shore, why do we* SEE *the small* MASTS *before we see the bulky* HULL ?

A. Because the *earth is round;* and the *curve* of the sea *hides the hull* from our eyes, after the tall *masts* have become visible.



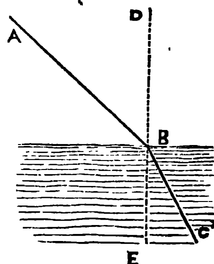
Here only that part of the ship above the line AC, can be seen by the spectator A; the rest of the ship is hidden by the swell of the curve DE.

Q. *What is meant by* REFRACTION ?

A. The *bending* of a *ray of light,* as it passes from one medium to another.

Q. How *is a ray of light* BENT, *as it passes from one medium to another?*

A. When a ray of light passes into a *denser* medium, it is bent *towards* the perpendicular. When it passes into a *rarer* medium, it is bent *from* the perpendicular.



Suppose DE to be a perpendicular line.

If AB (a ray of light) enters the water, it will be bent *towards* the perpendicular to C.

If (on the other hand) CB (a ray of light) emerges *from* the water, it would be bent *away from* the perpendicular, towards A.

Q. *Why does a* SPOON *(in a glass of water) always appear* BENT?

A. Because the light (reflected from the spoon) is *refracted,* as it *emerges from the water.*

And the spoon looks like ABC. (*See the last figure.*)

Q. *Why does a river always appear more shallow, than it really is?*

A. Because the light of the bottom of the river is REFRACTED, as it emerges out of the water: and (as a stick is not so long when it is *bent*, as when it is *straight*) so the river seems less deep, than it really is.

Q. *How much deeper is a river, than it seems to be?*

A. One-third. If, therefore, a river seems only 4 feet deep, it is really 6 feet deep.

N. B. Many boys get out of their depth in bathing, in consequence of this deception. Remember, a river is always one-third deeper, than it appears to be:—thus, if a river seems to be 4 feet deep, it is in reality 6 feet deep, and so on.

Q. *Why do fishes always seem to be nearer the surface of a river, than they really are?*

A. Because the rays of light from the fish are *refracted,* as they emerge from the eye: and (as a bent stick is not so far from end to end, as a straight one), so the fishes appear nearer our eye, than they really are.

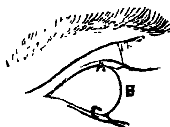
Q. *Why are some persons* NEAR-SIGHTED?

A. Because the COR'NEA of their eye

is so *prominent*, that the image of distant objects is formed, *before it reaches* the RET'INA; and, therefore, is not distinctly seen.

Q. *What is meant by the* "COR'NEA *of the* EYE?"

A. All the *outside* of the visible part of the *eye-ball*.



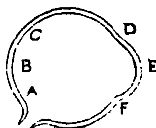
The curve ABC is called the COR'NEA.

If this curve be too prominent (or convex), the eye is near sighted.

If too flat (or concave), the eye is far-sighted.

Q. *What is meant by the* "RET'INA *of the* EYE?"

A. The net-work, which lines the *back of the eye*, is so called.



The net work ABC is called the ret'-ina, and the projecting part DEF is called the cor'nea.

N. B. This net-work is composed of a spreading-out of the fibres of the nerve of vision.

Q. *What sort of* GLASSES *do* NEAR-SIGHTED *persons wear?*

A. If the cor'nea be *too convex* (or

projecting), the person must wear double *concave glasses*, to counteract it.

Q. *What is meant by* "DOUBLE CONCAVE GLASSES?"

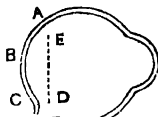
A. Glasses hollowed-in *on both sides.*



The figure A is double concave, or concave on both sides.

Q *What is meant by the* "IMAGE *of objects being formed*, BEFORE *it reaches the* RET'INA?"

A. If the cor'nea be *too convex*, the image of a distant object is formed in the *vitreous humours* of the eye, and not on the *ret'ina.*



Thus the image is formed at DE; and not on ABC (the retina).

Q. *What is the use of* DOUBLE CONCAVE SPECTACLE *glasses?*

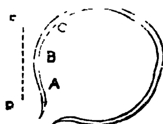
A. To *cast the image further back;* in order that it may be thrown upon the ret'ina, and become visible.

Q *Why are* OLD *people* FAR-SIGHTED?

A. Because the humours of their eyes are *dried up by age;* in consequence of which, the COR'NEA *sinks in,* or becomes flattened.

Q. *Why does the* FLATTENING *of the* COR'NEA *prevent persons seeing objects which are* NEAR?

A. As the cor'nea is *too flat,* the image of any near object is not *completely* formed, when the rays reach the RET'INA; in consequence of which, the image appears to be imperfect and confused.



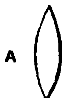
The perfect image is made at DE; and not on ABC (the retina).

Q. *What sort of* GLASSES *do* OLD *people* WEAR?

A. As their cor'nea is *not sufficiently convex,* they must use *double convex glasses,* to enable them to see objects near at hand.

Q. *What sort of glasses are* "DOUBLE CONVEX SPECTACLE-GLASSES"?

A. Glasses which *curve outwards* on both sides.



The figure A is double convex, or convex on both sides.

Q. *What is the* USE *of* DOUBLE CONVEX *spectacle-glasses?*

A. They *shorten the focus of the eye;* and (if a person be far-sighted) bring the image *into the eye,* upon the ret'ina.

Q. *Why do* NEAR-SIGHTED *persons bring objects* CLOSE *to the eye, in order to* SEE THEM?

A. As the distance between the *front and back of the eye is too great,* the image of distant objects is formed in *front* of the *ret'ina;* but when objects are brought very *near* to *the eye,* their image is thrown *further back,* and falls *on* the ret'ina.

Q. *Why do* OLD *people* HOLD *objects* FAR OFF, *in order to see them better?*

A. Because the distance between the *front and back of their eyes is not great enough;* and when objects are held further

off, this defect is compensated, and a perfect image formed on the ret'ina.

Q. *Why are* HAWKS *able to see such an* IMMENSE *way off?*

A. Because they have a muscle in the eye, which enables them to *flatten their cor'nea,* by drawing back the crystalline lens.

Q. *Why can* HAWKS *see objects within half-an-inch of their eye, as well as those a long way off?*

A. Because their eyes are furnished with a broad circular rim; which *confines the action of this muscle,* and throws the *cor'nea forward.*

Q. *Into how many* PARTS *may a* RAY *of* LIGHT *be* DIVIDED?

A. Into three parts: BLUE, YELLOW, and RED.

N.B. These three colours, by combination, make seven. 1.—RED. 2.—ORANGE (or red and yellow). 3.—YELLOW. 4.—GREEN (or yellow and blue). 5.—BLUE. 6.—INDIGO (a shade of blue). and 7.—VIOLET (or blue and red).

Q. *How is it known, that a ray of light consists of several different colours?*

A. Because, if a ray of light be cast upon a triangular piece of glass (called a prism), it will be distinctly divided into

seven colours: 1.—Red; 2.—Orange; 3.—Yellow; 4.—Green; 5.—Blue; 6.—Indigo; and 7.—Violet.

Q. *Why does a* PRISM DIVIDE *a ray of light into* VARIOUS COLOURS?

A. Because all these colours have *different refractive susceptibilities.* Red is refracted *least,* and blue the *most;* therefore, the *blue* colour of the ray will be bent to the *top* of the prism, and the *red* will remain at the *bottom.*



Here the ray AB (received on a prism), would have the blue part bent up to C; the yellow part to D; and the red part no further than E.

Q. *What is meant by the* REFRACTION *of a ray?*

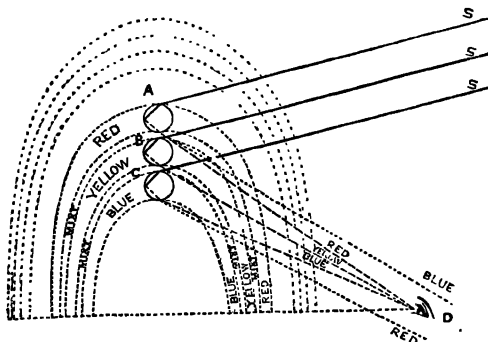
A. *Bending it* from its straight line.

Thus the ray AB of the last figure is refracted at B into three courses, C, D, and E.

Q. *What is the cause of a* RAINBOW?

A. When the clouds opposite the sun *are very dark,* and rain is *still falling* from them, the rays of the bright sun *are*

divided by the rain-drops, as they would be by a prism.



Let A, B, and C be three drops of rain; SA, SB, and SC, three rays of the sun. SA is divided into the 3 colours; the blue and yellow are bent *above* the eye D, and the *red* enters it.

The ray SB is divided into the three colours; the blue is bent *above* the eye, and the red falls *below* the eye D; but the *yellow* enters it.

The ray SC is also divided into the three colours. The blue (which is bent most) enters the eye; and the other two fall below it. Thus the eye sees the blue of C, and of all drops in the position of C; the yellow of B, and of all drops in the position of B; and the red of A, and of all drops in the position of A; and thus it sees a rainbow.

Q. *Does* EVERY *person see the* SAME *colours from the* SAME DROPS?

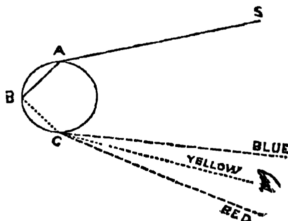
A. No; *no two persons* see the *same rainbow.*

To another spectator the rays from SB might be *red*, instead of yellow; the ray from SC, yellow; and the blue might be reflected from some drop below C. To a *third* person the red may issue from a drop above A, and then A would reflect the yellow, and B the blue, and so on.

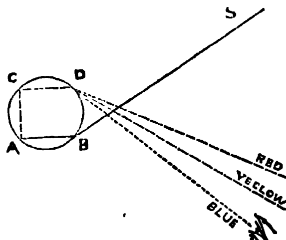
Q. *Why are there often* TWO RAINBOWS, *at one and the same time?*

A. In *one* rainbow we see the rays of the sun *entering the rain-drops at the top,* and reflected to the eye *from the bottom.*

In the *other* rainbow, we see the rays of the sun *entering the rain-drops at the bottom,* and reflected to the top, whence they reach the eye.



Here the ray SA strikes the drop at A,—is refracted or bent to B,—is then reflected to C, where it is refracted again, and reaches the eye of the spectator. (*See p.* 414).



Here the ray SB strikes the drop at B,—is refracted to A,—is then reflected to C,—is again reflected to D, when it is again refracted or bent, till it reaches the eye of the spectator.

Q. *Why are the* COLOURS *of the* SECOND *bow all* REVERSED?

A. Because in *one* bow we see the rays, which enter at the *top* of the rain-drops, *refracted from the bottom:*

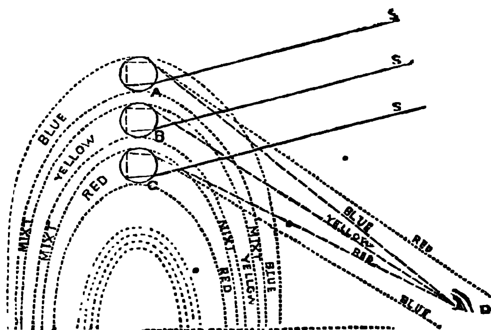
But in the *other* bow we see the rays, which enter at the *bottom* of the rain-drops (after two reflections), *refracted from the top.*

See figure on next page.

Here ABC, represent three drops of rain in the PRIMARY (or inner) RAINBOW.

The *least* refracted line is RED, and BLUE the *most.*

So the RED (or *least* refracted rays) of all the drops in the position of A,—the YELLOW of those in the position of



B,—and the BLUE (or the *most* refracted rays) of the lowest drops, all meet the eye D, and form a rainbow to the spectator.

The reason why the primary bow exhibits the stronger colours is this—because the colours are seen after *one* reflection and *two* refractions; but the colours of the secondary (or upper) rainbow, undergo *two* reflections and *two* refractions.

(*See figure on p.* 412.) Here also the *least* refracted ray is RED, and the *most* refracted BLUE (as in the former case); but the position of each is reversed.

Q. *Why does a* SOAP BUBBLE *exhibit such* VARIETY *of* COLOURS?

A. The changing colour of the bubble depends upon the changing *thickness of the film* through which the ray passes.

Q. *How does the* THICKNESS *of the* FILM *affect the* COLOUR *of the soap bubble?*

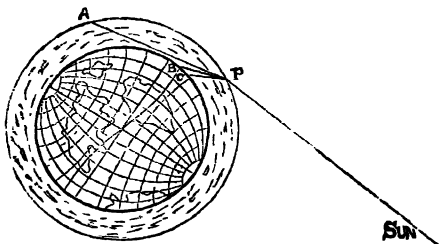
A. Because different *degrees of thickness* in the film produce different *powers of refraction;* and, therefore, different colours reach the eye.

Q. *Why is the* SOAP BUBBLE *so constantly* CHANGING *its* THICKNESS?

A. As the bubble is *suspended,* the water *runs down from the top* to the bottom of the bubble, till the crown becomes so *thin* as to burst.

Q. *Why are the late* EVENING CLOUDS RED?

A. Because the sun's rays have to traverse a great *thickness of atmosphere;* and as RED rays are the *least refrangible,* they are the *last* to disappear.



Here it will be seen that the red ray PA, may be visible; while the YELLOW and BLUE rays are hidden by the curve of the earth.

Q. *Why are the early* MORNING *clouds* RED?

A. Because the sun's rays have to traverse a great *thickness of atmosphere;* and as RED rays are the *least refrangible,* they are the *first* to appear.

See last figure.—It is evident that PA (the red rays) will be visible, before either the yellow or blue ones.

Q. *What becomes of the* BLUE *and* YELLOW *rays?*

A. They are refracted *below* the horizon, and are made invisible by the *curve* of the earth. *(See last figure.)*

Q. *Why are the* EDGES *of* CLOUDS *more* LUMINOUS, *than their* CENTRES?

A. Because the *body of vapour* is *thinnest* at the edges of the clouds.

Q. *What is the cause of morning and evening* TWILIGHT?

A. When the sun is below the horizon, the rays (which strike upon the atmosphere or clouds) are *bent down towards the earth,* and produce a little light, called twilight.

See figure on p. 416.—Here the rays of PA will give *some* light.

Q. WHY *is a ray of* LIGHT *composed of* VARIOUS COLOURS?

A. If solar light were of *one colour only,* all objects would appear of *that one colour,* or else black.

Q. *Why are some things of* ONE COLOUR, *and some of* ANOTHER?

A. As every ray of light is composed of all the colours of the rainbow; *some* things reflect *one of these colours,* and some *another.*

Q. WHY *do some things reflect* ONE COLOUR, *and some* ANOTHER?

A. Because the *surface* of things is so *differently constructed,* both physically and chemically; and, therefore, *some* things reflect *one* ray; some *two rays;* some *all* the rays; and some *none.*

Q. *Why is a* ROSE RED?

A. Because the surface of a rose *absorbs* the *blue* and *yellow* rays of light, and *reflects* only the *red* ones.

Q. *Why is a* VIOLET BLUE?

A. Because the surface of the violet *absorbs* the *red* and *yellow* rays of the sun, and *reflects* the *blue* only.

Q. *Why is a* PRIMROSE YELLOW ?

A. Because the surface of the primrose *absorbs* the *blue* and *red* rays of solar light, and *reflects* the *yellow* ones.

Q. *Why are some things* BLACK ?

A. Because they *absorb all the rays* of light, and reflect *none.*

Q. *Why are some things* WHITE ?

A. Because they *absorb none of the rays* of light, but reflect them *all.*

Q. *Why are* COALS BLACK ?

A. Because they *absorb all the rays of the sun,* which impinge upon them.

Q. *Why are* SNOW, SUGAR, *and* SALT, WHITE ?

A. Because they consist of a vast number of small crystals, which reflect the various rays of light from different points; and as these crystals are very numerous, the colours *unite again* before they meet the eye, and *appear white.*

N. B. The combination of *all* colours makes WHITE.

Q. *Why are the* LEAVES *of plants* GREEN ?

A. Because a peculiar chemical principle, called chlo'rophyll,* is formed within their *cells;* which has the property of

* Chlo'rophyll (χλωρον φυλλον, a green leaf) is the green matter of vegetable substances.

absorbing the *red* rays, and of reflecting the blue and yellow, which (being mixed together) produce *green.*

Q. *Why are leaves a* LIGHT *green in* SPRING?

A. Because the chlo'rophyll is not fully formed.

Q. *Why are leaves a* YELLOWISH BROWN *in* AUTUMN?

A. Because the chlo'rophyll undergoes *decay;* and is not replaced, as it is in spring.

Q. *Why are plants a* PALE YELLOW, *when kept in the* DARK?

A. Because chlo'rophyll can be formed only by the agency of the *sun's rays.*

Q. *Why are* POTATOES YELLOW?

A. Potatoes are grown *underground;* and, therefore can form no chlo'rophyll in their tubers.

Q. *Why are potatoes (which grow* EXPOSED *to the air and light)* GREEN?

A. Because chlo'rophyll is formed in them, under the influence of the sun's light.

Q. *Why are* SOME *things (like glass)* TRANSPARENT?

A. In transparent bodies (like glass) all the rays of light *emerge on the opposite side.*

Q. *Why are* SOME *things* SHINING *and others* DULL?

A. Because some things *reflect* rays, and are *bright;* but others *absorb* them, and are *dull.*

Q. *Why are* DESERTS *so* DAZZLING *in summer time?*

A. Because each separate grain of sand *reflects the rays of the sun,* like a mirror.

Q. *If you move a stick (burnt at one end)* ROUND *pretty briskly, it seems to make a* CIRCLE OF FIRE,—WHY *is this?*

A. Because the eye *retains the image* of any bright object, *after the object itself is withdrawn;* and as the spark of the stick returns, *before the image has faded* from the eye, therefore, it seems to form a *complete circle.*

Q. *If separate figures (as a man and a horse) be drawn on separate sides of a card, and the card* TWISTED *quickly, the man will seem to be seated on the horse,*—WHY *is this?*

A. Because the image of the horse *remains upon the eye,* till the *man* appears.

The Thaumatrope is constructed on this principle.

Q. *Why do the* STARS TWINKLE?

A. Fixed stars are *so far off,* that their rays of light do not strike upon the eye *in a continuous flow,* but at *intervals:* during these intervals, the star is *invisible;* and this *perpetually* occurring, makes a kind of *twinkling.*

Some persons say, that the stars are so far off, that the minutest opaque particles, floating between them and the eye, will obscure them for the moment; and that these frequent obscurations produce the twinkling.

Q. *If we look at a* RED-*hot* FIRE *for a few minutes,* WHY *does every thing seem* TINGED *with a* BLUISH GREEN *colour?*

A. Because bluish green is the "ACCIDENTAL COLOUR" of red: and if we fix our eye upon *any colour whatsoever,* when we turn aside, we see every object tinged with *its accidental colour.*

Q. *What is meant by the* ACCIDENTAL COLOUR?

A. The colour, which would be required to be added, in order to make up *white* light.

Q. *Why does the eye perceive the* ACCIDENTAL COLOUR, *when the fundamental one is removed?*

A. Because the nerve of the eye has become tired of the one, but still remains fresh for the perception of the *other*.

Q. *If we wear* BLUE GLASSES, *why does every thing appear tinged with* ORANGE, *when we take them off.*

A. Because *orange* is the "*accidental colour*" of blue: and if we look through *blue glasses*, we shall see its "*accidental colour*," when we lay our glasses aside.

Q. *If we look at the* SUN *for a few moments, every thing seems tinged with a* VIOLET *colour,*— WHY *is this?*

A. Because *violet* is the "accidental colour" of *yellow;* and as the sun is *yellow*, we shall see its "accidental colour" *blue*, when we turn from gazing at it.

Q. *Does not the* DARK SHADOW *(which seems to hang over every thing, after we turn from looking at the sun) arise from our eyes being* DAZZLED?

A. Partly so: the pupil of the eye is *very much contracted* by the brilliant light of the sun, and does not adjust itself immediately to the feebler light of terrestrial objects; but, independent of this,

the "ACCIDENTAL COLOUR" of the sun being *dark violet*, would tend to throw a shadow upon all things. (*See p.* 383).

Q. *Why is* BLACK *glass for spectacles the* BEST *for wear, in this respect?*

A. Because *white* is the accidental colour of *black;* and if we wear *black glasses*, every thing will appear *in white light*, when we take them off.

Q. *Why does every thing seem shadowed with a* BLACK MIST, *when we take off our common* SPECTACLES?

A. Because the glasses are *white;* and black being its "accidental colour," every thing appears in a *black shade*, when we lay our glasses down.

The accidental colour of red	is bluish green.
" " " of orange	" blue.
" " " of violet	" yellow.
" " " of black	" white.

And the converse of this is true:—

The accidental colour of bluish green	**is red.**
" " " of blue	**" orange.**
" " " of yellow	**" violet.**
" " " of white	**" black.**

(The law of an accidental colour is this—The accidental colour is always half the spectrum. Thus, if we take half the length of the spectrum by a pair of compasses, and fix one leg in any colour, the other leg will hit upon its accidental colour.)

N. B. The spectrum means the seven colours (red, orange, yellow, green, blue, indigo, and violet,) divided into seven equal bands, and placed side by side in the order just mentioned.

CHAPTER XXVIII.

SOUND.

Q. *How is* SOUND *produced?*

A. The vibration of some sonorous substance produces motion in the air, called SOUND WAVES; which strike upon the *drum of the ear*, and give the sensation of sound.

Q. *What are* MUSICAL SOUNDS?

A. Regular and uniform successions of vibrations.

Q. *How* FAST *does* SOUND TRAVEL?

A. About 13 miles in a minute, or 1142 feet in a second of time.

Light would go 8 times round the whole earth, while sound is going its 13 miles.

Q. *Why are* SOME *things* SONOROUS, *and others* NOT?

A. The sonorous quality of any substance, depends upon its *hardness and elasticity.*

Q. *Why are* COPPER *and* IRON SONOROUS, *and not* LEAD?

A. Copper and iron are *hard and elastic;* but as lead is neither hard nor yet elastic, it is *not sonorous.*

Q. *Of what is* BELL-METAL *made?*

A. Of *copper and tin* in the following proportions;—In every 5 pounds of bell-metal, there should be 1 lb. of tin, and 4 lbs. of copper.

Q. *Why is this mixture of tin and copper used for* BELL-METAL?

A. Because it is much *harder* and more *elastic,* than any of the pure metals.

Q. *Why is the* SOUND *of a bell* STOPPED, *by* TOUCHING *the bell with our finger?*

A. The weight of the finger *stops the vibrations* of the bell; and as soon as the bell *ceases to vibrate,* it ceases to make sound-waves in the air.

Q. *Why does a* SPLIT BELL *make a hoarse disagreeable sound?*

A. The *split* of the bell causes a *double vibration;* and as the sound-waves *clash and jar,* they impede each other's motion, and produce discordant sounds.

Q. *Why does a* FIDDLE-STRING *give a musical sound?*

A. The bow drawn across the string *causes it to vibrate;* and this vibration of the string *sets in motion the sound-waves of the air,* and produces musical notes.

Q. *Why does a* DRUM *sound?*

A. The parchment head of the drum *vibrates* from the blow of the drum-stick, and sets in motion the sound-waves of the air.

Q. *Why do* MUSICAL GLASSES *give sounds?*

A. Because the glasses *vibrâte* as soon as they are struck, and set in motion the sound-waves of the air.

Q. *Why do* FLUTES, *&c. produce musical sounds?*

A. The breath of the performer causes the *air in the flute* to *vibrate;* and this vibration sets in motion the sound-waves of the air.

Q. *Why do* PIANO-FORTES *produce musical sounds?*

A. Each *key of the piano* (being struck with the finger) lifts up a little hammer, which *knocks against a string;* and the vibration thus produced, sets in motion the sound-waves of the air.

Q. *Why are* SOME *notes* BASS, *and some* TREBLE?

A. *Slow* vibrations produce *bass or deep sounds;* whereas *quick* vibrations produce *shrill or treble sounds.*

Q. *Why is an instrument* FLAT, *when the* STRINGS *are* UNSTRUNG?

A. Because the vibrations are *too slow;* in consequence of which, the sounds produced are not *shrill* or *sharp* enough.

Q. *Why can persons, living a mile or two from a town,* HEAR *the* BELLS *of the town-church* SOME TIMES, *and not at* OTHERS?

A. Fogs, rain, and snow, obstruct the passage of sound; but when the air is *cold and clear,* sound is propagated more easily.

Q. WHY *can we* NOT *hear sounds (as those of*

distant church bells) in RAINY *weather, so well as in* FINE *weather?*

A. Because the falling rain *interferes with the undulations of the sound-waves,* and breaks them up.

Q. *Why can we not hear sounds (as those of distant church bells) in* SNOWY *weather, so well as in* FINE *weather?*

A. Because the falling snow *interferes with the undulations of the sound-waves,* and stops their progress.

Q. *Why can we* HEAR *distant clocks* MOST *distinctly in* CLEAR COLD *weather?*

A. Because the air is of more *uniform density,* and generally *still;* and there are no *currents of air* to interrupt the sound-waves.

Q. *Why can persons (near the* POLES), *hear the* VOICES *of men in conversation for a* MILE *distant, in winter time?*

A. Because the air is very *cold, clear,* and *still;* in consequence of which, there are no *currents of air* to interrupt the sound-waves.

Captain Ross heard the voices of his men in conversation, a mile and a half from the spot where they stood.

Q. *Why are not* SOUNDS *(such as those of*

distant church bells) heard so distinctly on a HOT DAY, *as in* FROSTY *weather?*

A. 1st—Because the density of the air is less *uniform* in very hot weather:

2ndly—It is more *rarefied;* and, consequently, a worse conductor of sound: and

3rdly—It is more liable to *accidental currents,* which impede the progress of sound.

Q. *Why can we not hear* SOUNDS *(such as those of distant clocks) so distinctly in a thick* MIST *or* HAZE, *as in a* CLEAR *night?*

A. Because the air is not of uniform density, when it is laden with mist; in consequence of which, the sound-waves are obstructed in their progress.

Q. *Why do we hear* SOUNDS *better by* NIGHT *than by* DAY?

A. 1st—Because night air is of *more uniform density,* and less liable to *accidental currents:* and

2ndly—Night is more *still,* from the suspension of business, and the cessation of the hum of men.

Q. *Why is the air of more* UNIFORM DENSITY *by* NIGHT, *than it is by day?*

A. Because it is less liable to accidental currents; inasmuch as the breezes (created by the action of the sun's rays) generally *cease* during the night.

Q. *How should* PARTITION WALLS *be made, to* PREVENT *the voices in adjoining rooms from being* HEARD?

A. The space between the laths (or canvass) should be filled with *shavings* or *saw-dust;* and then no sound would ever pass from one room to another.

Q. *Why would* SHAVINGS, *or saw-dust,* PREVENT *the transmission of sound from room to room?*

A. Because there would be *several different media* for the sound to pass through: 1st—the air; 2ndly—the laths and paper; 3rdly—the saw-dust or shavings; 4thly—lath and paper again; 5thly—the air again: And every change of medium diminishes the *strength of the sound-waves.*

Q. *Why can* DEAF *people hear through an* EAR-TRUMPET?

A. The ear-trumpet restrains *the*

spread of the voice, and limits the *diameter of the sound-waves;* in consequence of which, their *strength* is increased.

Q. *Why are* MOUNTAINS NOISELESS *and quiet?*

A. Because the air of mountains is *very rarefied;* and as the air becomes *rarefied,* sound becomes less *intense.*

Q. *How do you know, that the* RARETY *of air* DIMINISHES *the intensity of* SOUND?

A. If a bell be rung in the receiver of an air-pump, the sound becomes *fainter and fainter,* as the air is exhausted; till at last it is quite *inaudible.*

Q. *What is the cause of* ECHO?

A. Whenever a sound-wave strikes against any *obstacle* (such as a wall or hill), *it is reflected* (or thrown back); and this *reflected sound* is called an ECHO.

The same laws govern echo as light. (*See p.* 370).

Q. *What places are most* FAMOUS *for* ECHOES?

A. Caverns, grottoes, and ruined abbeys; the areas of halls; the windings of long passages; the aisles of cathedral churches; mountains, and icebergs.

Q. *Why are caverns, grottoes, and ruins,* FAMOUS *for* ECHOES ?

A. 1st—Because the sound-waves cannot pass *beyond* the cavern or grotto, and, therefore, *must flow back:* and

2ndly—The *return-waves* (being entangled by the cavern) are *detained* for a short time, and come *deliberately* to the ear.

Q. *Why are halls, winding passages, and cathedral aisles,* FAMOUS *for* ECHOES ?

A. Because the sound-waves *cannot flow freely forward;* but strike against the winding walls perpetually, and are beaten *back.*

Q. *Why are* MOUNTAINS *and ice-bergs* FAMOUS *for* ECHOES ?

A. Because they present a *barrier* to the sound-waves, *which they cannot pass;* and are sufficiently elastic to *throw them back.*

Q. *Why do not the* WALLS *of a* ROOM *or church produce* ECHO ?

A. Because sound travels with such *velocity,* that the echo is *blended with the*

original sound; and the two produce but *one impression* on the ear.

Sound travels 13 miles in a minute; and no echo is heard, unless the surface (against which the sound strikes) is 65 feet from the place, whence the sound originally proceeded.

Q. *Why do very* LARGE *buildings (as cathedrals), often* REVERBERATE *the voice of the speaker?*

A. Because the walls are *so far off from the speaker*, that the echo does not *get back in time* to blend with the original sound; and, therefore, *each* is heard separately.

Q. *Why do* SOME *echoes repeat only* ONE *syllable?*

A. The *further* the echoing body is *distant*, the *more sound* it will *reflect:* If, therefore, the echoing body be *near*, it will repeat but one syllable.

Q. *Why does an* ECHO *sometimes repeat* TWO *or more syllables?*

A. Because the echoing body is *far off;* and, therefore, there is time for one reflection *to pass away*, before *another* reaches the ear.

N.B. All the syllables must be *uttered*, before the echo of the first syllable reaches the ear—If, therefore, a person repeats 7 syllables in 2 seconds of time, and hears them *all* echoed, the reflecting object is 1142 feet distant; (because

sound travels 1142 feet in a second, and the words take one second to *go to* the reflecting object, and one second to *return*).

Q. *Why are* TWO *or more* ECHOES *sometimes heard?*

A. Because separate reverberating surfaces receive the sound, and reflect it in succession.

17 miles above Glasgow (Scotland) near a mansion called Rosneath, is a very remarkable echo. If a trumpeter plays a tune and stops, the echo will begin the same tune and repeat it all accurately;—as soon as this echo has ceased, *another* will echo the same tune in a lower tone; and after the second echo has ceased, a *third* will succeed with equal fidelity, though in a much feebler tone.

At the Lake of Kilkarney in IRELAND, there is an echo which plays an excellent "*second*" to any simple tune played on a bugle.

Q. *Why do* WINDOWS RATTLE, *when* CARTS *pass by a house?*

A. 1st—Because glass is *sonorous;* and the air communicates its vibrations to the glass, which echoes the same sound: and

2ndly--The *window-frame* being *shaken*, by the sound-waves *impinging against the window*, contributes to the noise.

CHAPTER XXIX.

MISCELLANEOUS.

Q. *Why do the* BUBBLES *in a* CUP OF TEA *range round the* SIDES *of the* CUP?

A. Because the cup *attracts them.*

Q. *Why do all the* LITTLE BUBBLES *tend towards the* LARGE *ones?*

A. Because the large bubbles (being the superior masses) *attract them.*

Q. *Why do the* BUBBLES *of a* CUP OF TEA FOLLOW *a* TEA-SPOON?

A. Because the tea-spoon *attracts them.*

Q. *Why are the* SIDES *of a pond covered with* LEAVES, *while the* MIDDLE *of the pond is quite* CLEAR?

A. Because the shore *attracts* the leaves to itself.

Q. *Why do all fruits, &c. (when severed from the tree)* FALL *to the* EARTH?

A. Because the earth *attracts them.*

Q. *Why do persons (who water* PLANTS) *very*



often pour the water into the SAUCER, *and not* OVER *the* PLANTS?

A. Because the water in the saucer is *drawn up* by the mould (through the hole at the bottom of the flower-pot), and is transferred to the stem and leaves of the plant by CAPILLARY ATTRACTION, (*See p.* 76).

Q. *Why is vegetation on the* MARGIN *of a* RIVER *more* LUXURIANT, *than in an open* FIELD?

A. Because the porous earth on the bank *draws up water* to the roots of the plants by CAPILLARY ATTRACTION.

Q. *Why is a* LUMP *of* SUGAR *(left at the bottom of a cup) so* LONG *in* MELTING?

A. Because (as it melts) it makes the tea above it *heavier*; and (so long as it remains at the bottom) is surrounded by tea fully *saturated* with sugar; in consequence of which, the *same* portions of liquid will hold *no more sugar in solution.*

Q. *Why does the* LUMP *of* SUGAR MELT *more* QUICKLY, *when* STIRRED ABOUT?

A. Because *fresh portions of unsaturated tea* come in contact with the lump, and soon dissolve it.

Q. *Why does a* PIECE OF SUGAR *(held in a spoon at the* TOP *of our tea) melt very* RAPIDLY?

A. Because as the tea becomes *sweetened,* it *descends to the bottom of the cup* by its own gravity; and *fresh* portions of unsweetened tea are brought constantly into contact with the sugar, till the lump is entirely dissolved.

Q. *How can a* SICK ROOM *be kept* FREE *from unhealthy* EFFLUVIA?

A. By sprinkling it with vinegar boiled with myrrh, or camphor.

Q. *Why does* LIME *destroy the offensive smells of* BINS, SEWERS, *&c.*

A. Because it decomposes the offensive gases upon which the smell depends, and destroys them.

Q. *Why does* CHLORIDE *of* LIME *fumigate a sick room?*

A. Because the chlorine absorbs the *hydrogen of the stale air;* and by this means removes both the *offensive smell,* and the *infection* of a sick room.

Q. *How can the* TAINT *of* MEAT *be removed?*

A. Either by washing with PYROLIG-

NEOUS ACID,—covering it for a few hours with common CHARCOAL,—or by putting a *few lumps of charcoal* into the *water in which it is boiled.*

Q *Why do these things* DESTROY *the* TAINT *of meat?*

A. Because they *combine* with the *putrescent particles,* and neutralize their offensive taste and smell.

Q. *Why should* BED-ROOMS, COTTAGES, HOSPITALS, *and* STABLES, *be washed occasionally with* LIME-WHITE?

A. Because the lime *is very caustic,* and removes all organic matters adhering to the walls.

Q. *Why will strong* SOUCHONG TEA POISON FLIES?

A. Because it contains *prussic acid,* which destroys their *nervous system.*

Q. *Why is strong* GREEN TEA UNWHOLESOME?

A. Because it contains *prussic acid,* which destroys the *nervous system.*

Q. *Why is a* DEAD *man* TALLER *than a living one?*

A. Because at death the CARTILAGES are *relaxed.* So, also, after a night's

rest, a man is *taller,* than when he went to bed.

Q. *What is* SLEEP?

A. Sleep is the *rest of the brain,* and *nervous system.*

Q. *Why can we not* SEE, *when we are asleep with our* EYES OPEN?

A. Because the "RET'INA of the eye" is *inactive* and at rest.

Q. *Why can we not* HEAL *in sleep?*

A. Because the nerve of hearing (seated within the TYMPANUM of the ear) is at rest.

Q. *Why can we not* TASTE, *when we are asleep?*

A. Because the nerves *at the end of the tongue* (called papillæ) are inactive and at rest.

Q. *Why can we not* FEEL, *when we are asleep?*

A. Because the *ends of the nerves* (called papillæ) situated in the -skin, are inactive and at rest.

Q. *Why have persons in sleep no* WILL *of their own, but may be moved at the will of* ANY *one?*

A. Because the "CEREBELLUM" (or *posterior* part of the brain) is inactive and at rest.

Q. *Why have* DREAMERS *no power of* JUDGMENT *or* REASON ?

A. Because the "CEREBRUM" (or *front* of the brain) is inactive and at rest.

Q. *Why do some persons* LOSE *all* POWER *of* SENSATION ?

A. Because the "CEREBRUM" (or *front* of their brain) *has been injured.*

Q. *Why does a person* FEEL, *when he is* TOUCHED ?

A. Because the ends of certain nerves (called PAPILLÆ) situated in the skin are *excited;* and produce a nervous sensation, called FEELING.

Q. *Why are persons able to* TASTE DIFFERENT FLAVOURS ?

A. Because the "PAPILLÆ" of the tongue and palate are *excited,* when food touches them; and produce a nervous sensation, called TASTE.

Q. *Why are* OLD *people* UNABLE *to* WALK ?

A. Because their *muscles become rigid.*

GLOSSARY.

ACETIC ACID,	commonly called	Distilled Vinegar.
CITRIC ”	”	Juice of Lemons.
NITRIC ”	”	Aqua Fortis.
OXALIC ”	”	Salt of Lemons.
SULPHURIC ”	”	Oil of Vitriol.
SULPHATE OF LIME	”	Plaster of Paris.
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